

The **COAST GUARD** Journal of Safety
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Spring 2016

Safety Management Systems

*From the boardroom to the boiler room
there can be no weak links*



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Assistant Commandant's Perspective

by REAR ADMIRAL PAUL F. THOMAS
Assistant Commandant for Prevention Policy
U.S. Coast Guard

The topic of this *Proceedings* edition is very important to me as the Assistant Commandant for Prevention Policy, but it is also a critical issue for the global maritime industry, the International Maritime Organization, and the countries who oversee the safe transportation of cargo on the high seas.

Since the adoption of the International Safety Management Code more than 20 years ago, the safety management system (SMS) has been consistently pointed to as the maritime industry's primary means of mitigating risk. As a result, the maritime industry and the Coast Guard have steadily become more reliant on safety management systems to identify and mitigate risk, ensuring a systematic and consistent approach to safety and environmental stewardship.

The maritime industry is growing in complexity regarding vessel design and construction, requiring a commensurate increase in governing standards, regulatory schemes, numbers and types of parties involved, and legal and liability relationships. All of these factors raise our level of dependency on the safety management system.

There is no doubt in my mind that these systems are key to operating safely in a complex environment, but they must be robust—and robustly implemented. The challenge for the maritime industry, the Coast Guard, and third-party auditors is to ensure that the SMS is maintained, utilized, and remains an effective tool to identify and reduce risk.

There is nothing more dangerous than the false sense of security that comes with a safety management system that exists on paper only. Too often I've had to meet with maritime executives to discuss a significant safety or environmental incident they experienced. These executives tell me about their great safety management systems and the strong culture they've put into place, but they've still had a serious incident that a safety management system is designed to prevent.

An effective SMS must not only be very well developed in terms of process and procedures; it must also be deployed from the boardroom to the boiler room. There shouldn't be any disconnect between the auditors and the surveyors, or between the CEO and the seaman. We all must work together to discover and eliminate such disconnects.

I greatly appreciate the time, effort, and expertise of this issue's contributors, who were selected to represent all aspects of the maritime industry as well as the government. I hope that you will enjoy this issue of *Proceedings* and gain a more comprehensive understanding of the wide range of safety management system experiences and concerns represented here.

Champion's Point of View



by CAPT DAVID M. FLAHERTY
Chief, Traveling Inspection Staff
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This issue of *Proceedings* focuses on the role an effective safety management system (SMS) plays in identifying and mitigating risk to safeguard vessel passengers and crew, protect the marine environment, and prevent damage to the ship and/or its cargo.

There has been—and always will be—inherent risk associated with any commercial vessel operation. Within the maritime realm, engineering systems may break down, alarms may fail, expected weather conditions may change, or a crewmember may forget to perform a task. Any or all of these circumstances may affect—and in fact *have* affected—vessel safety.

For more than 20 years, mariners have relied upon the safety management system to mitigate risk. However, there is concern within the Coast Guard that some areas of the maritime industry still don't accept or appreciate the benefits of maintaining a safety management system.

I'm sure everyone can agree that ignoring or dismissing risk will never end well. As a firm believer in Murphy's Law, I always remember this quote: "Anything that *can* go wrong, *will* go wrong" to focus myself when I am working on a complex project. This reminds me to be fully observant and knowledgeable of the risks involved and to purposely determine how they might be removed or mitigated. In my view, Murphy's Law promotes a safety-minded environment by reminding everyone that complacency does not resolve risk, and that safety is everyone's concern.

However, clear procedures and processes alone do not add up to an effective SMS. Training has to be an integral part of a safety management system to promote understanding of the processes as well as emphasize the need for communication to ensure that any discrepancies are discovered, resolved, and documented. Finally, everyone within the company—from the boardroom down to the boiler room—must embrace and promote an active safety culture. Without a comprehensive company safety culture, even the best-written, organized, and detailed SMS will not meet expectations, and risk will remain—with the potential to expand.

In conclusion, I want to offer my sincere thanks to the all of the authors who submitted articles on this important topic. I hope this edition will help readers understand and appreciate what a safety management system can do for a company's operation, as promoting a proactive safety culture is critically important to protect passengers; ships, crew, and cargo; and the environment.

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Safety Management Facilitates Safe Vessel Operation

Vessel systems, crew, and operations.

by LCDR AARON W. DEMO
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On July 1, 1998, the International Safety Management (ISM) Code was made mandatory for passenger vessels, tankers, and bulk carriers subject to the International Convention for the Safety of Life at Sea (SOLAS) on foreign voyages. All other vessel types were given an additional four years (until July 1, 2002) to comply.

The ISM Code

In many ways, the ISM Code was a radical philosophical departure from traditional IMO regulations that largely focused on ship design and equipment, as the code focused on the human element—and not just for those employed on the ship. The code also stressed the responsibility for shore-based company personnel to support and facilitate safe ship operation.

The code laid out a brief but comprehensive framework of key elements that are fundamental to a safety management system (SMS). For example, companies must document operations, procedures, and lines of communication between the shoreside and onboard vessel operations as well as establish a standardized process to identify nonconformities and hazardous situations to ensure they're addressed in a timely manner.

A Safety Culture

A vessel's SMS clearly identifies roles and responsibilities for all involved parties and documents how all issues and failures of systems should be addressed. Since International Safety Management Code implementation, the Coast Guard has discovered that employees and management must have 100 percent buy-in for safety management systems to be effective and create a true safety culture within a company.

I recently spent some time visiting several offshore supply vessel companies in the Gulf of Mexico, and it was clear that safety management systems helped improve the companies' daily vessel operations. Through my own experience as an offshore supply vessel master in the mid-1990s, I would have loved to have had a safety management system as a tool to streamline vessel operations, ensure the vessel maintained regulatory compliance, and ensure proper notification to the company.

I spoke to several vessel masters and port captains during my recent trip to Port Fourchon, Louisiana, and it was clear that the vessels' safety management systems were working as designed, with all involved parties committed to maintaining the vessels to the highest standard to ensure crew safety and security and protect the environment.

While a safety management system covers a broad scope of operations, the three primary areas addressed aboard vessels can be broken down into:

- vessel systems,
- vessel crews,
- vessel operations.

Vessel Systems

Vessels built over the last few years have very complex, integrated systems that often become more advanced at a rate that's hard to keep up with. To maintain vessel safety, it's critical to have a safety management system that highlights how these systems work as well as how to rectify problems or failures within the system. The SMS also provides a means to identify regimented system and equipment testing and maintenance to ensure everything works properly and all equipment operates within the manufacturer's specifications.

By establishing a repeatable and traceable maintenance system, crews can confirm tests are conducted properly and safely to ensure compliance and identify potential flaws before they become failures. In the event crews do identify failures, the SMS lays out a process to rectify deficiencies and ensure timely repairs.

Vessel Crews

The crew is the most important aspect of safety management system effectiveness, as crewmembers must be well trained and fully committed to implementation if the system is going to work. If a crewmember just pulls a binder off the shelf and checks off tasks using a “here are things I have to get done today” mentality, the SMS is destined for failure. Crewmembers must be concerned with improving vessel safety—not just making sure they survive the next audit without nonconformities.

There are numerous examples of cases where the Coast Guard boarded a vessel and, according to a recent audit of the SMS, all systems were working as they were supposed to, but the material condition of the vessel said otherwise. Cases like these demonstrate a lack of commitment by at least one of the involved parties.

Over the past several years, there have been more requirements placed on vessel crews than ever before, and the SMS helps to identify what training and qualifications are needed for specific positions. The system even identifies individual crewmember roles and responsibilities, so everyone on the vessel is aware of what’s expected of them. Emergency plans are also incorporated into the vessel’s SMS to ensure that vessel crews are prepared to respond to potential scenarios in the event of an emergency and know their roles, should the need for action arise.

Vessel Operations

The goal of the safety management system is to ensure the vessel is operated in a way that takes the crew’s as well as the environment’s safety into account. Vessel owners can ensure the ship is operating in the safest, most efficient means possible by following the procedures for conducting vessel daily operations clearly laid out in the SMS.

It is imperative that the vessel master ensures these procedures are followed. When the ISM Code was first implemented, there were many off-the-shelf safety management systems that did not accurately describe what was actually being done in practice. If the SMS isn’t practical or doesn’t reflect current onboard operations for that specific vessel, the master should work with the company to address the deficiency and make corrections to the SMS as necessary. The safety management system is then a living document



The author, LCDR Demo (right), discusses vessel operations with the vessel master. U.S. Coast Guard photo by LCDR Lee Bacon.

specifically made for the individual vessel the system supports.

Additionally, the safety management system only works if the company and the vessel’s master actively use it. If crews conduct operations outside of the SMS and not as per the approved plan, then the safety management system will fail, which could result in a marine casualty. Similarly, if shoreside personnel don’t provide sufficient resources for the crew to perform needed maintenance, then safety will degrade.

Further, process effectiveness must constantly be evaluated, as maintenance levels that worked well when the ship was 10 years old might barely be adequate when the ship turns 20. Constant evaluation and corrective action ensures that processes are effective for each specific ship and its operations.

Achieving regulatory compliance goals in a consistent, sustained manner is a hallmark of an effective SMS, as the goal of the safety management system is to be out ahead of problems rather than waiting and only providing correction when failures occur.



The author, LCDR Demo (right), discusses a liquefied natural gas fuel system. U.S. Coast Guard photo by LCDR Lee Bacon.

ISM Code Certification Delegation

Like many flag administrations, the United States elected to delegate authority to recognized organizations (ROs) to conduct ISM audits and issue ISM certificates on behalf of the Coast Guard. All of the recognized organizations delegated ISM authorization are also Coast Guard-recognized classification societies. ROs for ISM Code certification currently include:

- ABS,
- DNV-GL,
- RINA, and
- Class NK.

It is not required that a U.S.-flagged vessel use the same recognized organization for ISM as they do for classification, and some companies have expressly elected to use a recognized organization separate from their ship's classification society to gain an independent evaluation of their company and vessel operations.

This is a well-intentioned motive, but vessel owners need to be aware that it reduces the free flow of information between

those who survey the ship and those who audit the SMS. In cases where two separate ROs are employed for a vessel or company, the Coast Guard and the owner must ensure that the surveyor and auditor enjoy unrestricted access to relevant information.

In the mid-1990s, the audit and survey were viewed as wholly separate, unconnected activities. With the passage of time, however, the Coast Guard and their recognized organizations have come to realize that good SMS process control leads to good conditions throughout the survey through factors such as preventative maintenance planning.

Recognizing that communication between auditors and surveyors is critical, the International Association of Classification Societies implemented Procedural Requirement 17 (PR 17) to allow surveyors to note conditions indicative of poor safety management and pass that information along either internally to their own class society ISM department or externally to the RO providing ISM certification. By agreement with our recognized organizations, the Coast Guard receives notice of all PR 17s issued to U.S.-flagged vessels, whereupon we fully engage with the RO to investigate.

Likewise, the Coast Guard is notified if a major nonconformity is noted during an audit of a U.S.-flagged vessel. Coast Guard and RO personnel then discuss downgrading a major nonconformity to nonconformances if the company initiates a root cause analysis as well as a corrective action plan. Otherwise, a major nonconformity is reason for the Coast Guard to suspend or revoke the ISM certificate. Where a major nonconformity has been downgraded, Coast Guard and recognized organization personnel evaluate whether or not the corrective action has been fully implemented.

When the RO conducts a follow-up audit within 90 days of the major nonconformity, in most instances, the Coast Guard will assign a marine inspector to attend the follow-up audit. The marine inspector and the RO personnel will then evaluate if the corrective action for the major nonconformity is sufficient.

Coast Guard stewardship over its recognized organization delegation for ISM Code is essential for full and effective implementation of the ISM Code on U.S.-flagged vessels.

About the author:

LCDR Aaron Demo is a graduate of Massachusetts Maritime Academy and has served in the U.S. Coast Guard for 15 years. He has also served as chief of the Inspections Division at Sector Houston-Galveston, assistant chief of the Domestic Vessel Branch at Sector Hampton Roads, and chief of the Incident Management Division at Sector New Orleans. Additionally, LCDR Demo holds a license as a 1600-ton Master Upon Oceans, Master of Towing Vessels Upon Oceans, and a Third Mate Unlimited Upon Oceans.

Safety Management Systems to Prevent Pollution from Ships

Standard procedures protect the environment.

by LCDR MICHAEL LENDVAY
Office of Commercial Vessel Compliance
U.S. Coast Guard

The U.S. receives approximately 9,000 foreign commercial ships per year that make more than 75,000 port calls.¹ These vessels on international voyages include container vessels, passenger vessels, and tank vessels, among other types. As a result, they must comply with a variety of international requirements, including the Safety of Life at Sea (SOLAS), the International Convention for the Prevention of Pollution from Ships (MARPOL).

A safety management system (SMS) is required under SOLAS, and sections of MARPOL require written procedures for garbage management, fuel switchover, and cargo transfers. Also, as part of the International Safety Management Code, every company must develop and implement a safety management system, which includes a safety and environmental policy as well as reporting requirements, authorities, communication channels, and audit procedures. Additionally, U.S. Coast Guard regulations require written fuel oil and/or cargo transfer procedures.

A good SMS contributes to ship and crew safety and helps ensure the ship is prepared to manage its environmental responsibilities, potentially reducing waste streams and the costs associated with waste disposal.

Waste Streams

Waste products on a ship must be properly processed onboard or sent to shore for processing and/or disposal. An efficient SMS addresses waste stream reduction and identifies proper processing and waste disposal methods. For example, a quality safety management system addresses proper machinery maintenance and repair to help engineers eliminate or at least minimize oil and fuel leaks that often mix with water in the bilge or leak out of equipment on

deck. This oily water mixture often results in heavier waste streams that may decrease overall efficiency and cause greater problems down the line.

The oil filtering discharge equipment onboard a ship, known as the oily water separator (OWS), processes lightly oiled water much more efficiently than heavy mixtures. Heavy mixtures require longer processing periods, which cause machinery to run longer and require additional servicing and cleaning—sometimes rendering the OWS unserviceable.

Garbage Management

Ships prevent pollution at sea by properly separating garbage and knowing when, where, and how to properly marshal and document garbage disposal. Implementing a

SMS Failure

The U.S. Coast Guard recently detained a vessel caught bypassing the oily water separator. In this case, crewmembers reported to Coast Guard personnel that some of the engineers ordered them to pump waste oily bilge water directly overboard through the marine sanitation device. This was counter to the vessel's safety management system and violated international regulations, as well.

When Coast Guard personnel conducted a port state control exam of the vessel, they found multiple grounds for detainment: oily residue in the marine sanitation device, discrepancies noted in the required oil record book, and oily waste water stored in unapproved tanks.

Detentions

Last year the U.S. Coast Guard issued 143 International Maritime Organization detentions.¹ The top three areas for detainable deficiencies were:

- International Safety Management (ISM) Code deficiencies,
- International Convention for the Prevention of Pollution from Ships (MARPOL) Annex I violations, and
- firefighting appliance deficiencies.

Of these detentions, 21 percent involved safety management, 17 percent were for MARPOL issues, and 17 percent were in regards to firefighting appliance deficiencies.

In most cases with ISM, it was clear that the master and crew were either not familiar with ISM requirements or failed altogether to properly conduct required ship equipment maintenance in accordance with their safety management system procedures.

With regard to MARPOL deficiencies, we continue to find vessel crews who attempt to bypass their oily water separators and discharge oily waste directly overboard. Other crews failed to conduct proper maintenance or didn't know how to operate equipment properly.

Firefighting deficiencies can be caused by poor equipment and also by not following safety management system procedures. One example we see too frequently is the intentional disabling of automatic water-based fixed firefighting systems.

Endnote:

¹ U.S. Coast Guard Port State Control Annual Report 2014.

good SMS that requires training and familiarization in these areas increases overall efficiency by greatly reducing the ship's environmental pollution potential and reducing costs associated with paying for unnecessary waste disposal.

This is particularly important due to the limited space onboard vessels and the need to retain much of the garbage. Under MARPOL Annex V, Prevention of Pollution by

Garbage from Ships, plastics may never be discarded overboard, and in special areas such as the Western Caribbean and Gulf of Mexico, very little other than food waste may be disposed of at sea.

Without a good safety management system and management plan, vessel operators face the possibility of fines or detention. However, with a good SMS with logs and proper documentation, port state control officers, ship management, and persons on shore can quickly determine compliance and ensure that illegal waste does not end up in the sea.

New Fuel Requirements

New requirements under MARPOL Annex VI, Prevention of Air Pollution from Ships, have gone into effect, lowering the allowed content of sulfur in fuel oil in the North American emission control area from 1 percent to 0.10 percent. While this new requirement will help improve air quality, particularly in areas along the coast, it has prompted additional areas of concern resulting from ship owners changing fuels and/or installing systems such as exhaust gas scrubbers to remove sulfur.

Changing fuels can cause problems if not done correctly. The compliant fuel burns at a lower temperature and different pressure than heavy fuel oil. Following the changeover, some vessels experienced leaks, requiring the crew to either switch back to the heavy fuel oil or make repairs and modifications to the fuel system's piping. Vessel operators can avoid such issues and better comply with new requirements without incident by properly implementing pre-established changeover procedures.

When adding new technology, such as exhaust gas scrubbers, operators should concurrently realize the need for additional safety management system procedures to properly operate, maintain, and report any system nonconformities. As new technology and systems are incorporated, vessel operators must update their procedures to address such developments.

About the author:

LCDR Lendvay has served in the Coast Guard for 17 years as a marine inspector and marine investigator. He is currently the port state control compliance manager in the Office of Vessel Compliance and has spent much of his career ensuring compliance with environmental laws and treaties.

Endnote:

¹ U.S. Coast Guard Port State Control Annual Report 2014.

Dead Reckoning by Safety Management?

Check your course.

by LCDR CORYDON F. HEARD IV
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On the evening of March 6, 1987, in the early moments of the passage from Zeebrugge, Belgium, to Dover, U.K., the roll-on/roll-off passenger/freight ferry *Herald of Free Enterprise* capsized while transporting 80 crewmembers and 459 passengers. Of those aboard, 193 perished.

In the immediate aftermath of the disaster, investigators determined that the main causal factor was failure to secure the inner and outer bow doors. As the case progressed, the formal investigation also identified several root causes within the corporate structure of the shore management that contributed to the disaster.

For example, the formal investigation specifically cited the shore management for failing to give proper and clear directions. These findings led the court to propose the safety management principles that eventually resulted in the International Safety Management (ISM) Code.

It's been more than two decades since ISM Code inception, and yet, as a recent Coast Guard enquiry concluded, the management practices that contributed to the *Herald of Free Enterprise* tragedy remain (see "Noncompliance" sidebar).

This is not to suggest that the design of the ISM Code itself is fundamentally flawed so much as, when compared to clearly prescriptive regulations, its orientation as a management system leaves it open to various interpretations. It is this degree of subjectivity that can complicate effective safety management system (SMS) implementation and challenge ISM Code administration. Therefore, to counterbalance this ambiguity, a clearer understanding of safety management system fundamentals is required.

A Functional System

By design, a safety management system is an integrated compilation of policies, procedures, and behaviors structured to ensure a formalized, proactive approach to safety management. Conceptually, and comparable to quality management systems, the role of leadership and organizational culture are paramount in ensuring that safety policies, rules, and processes are effectively implemented, reviewed, and continuously improved.

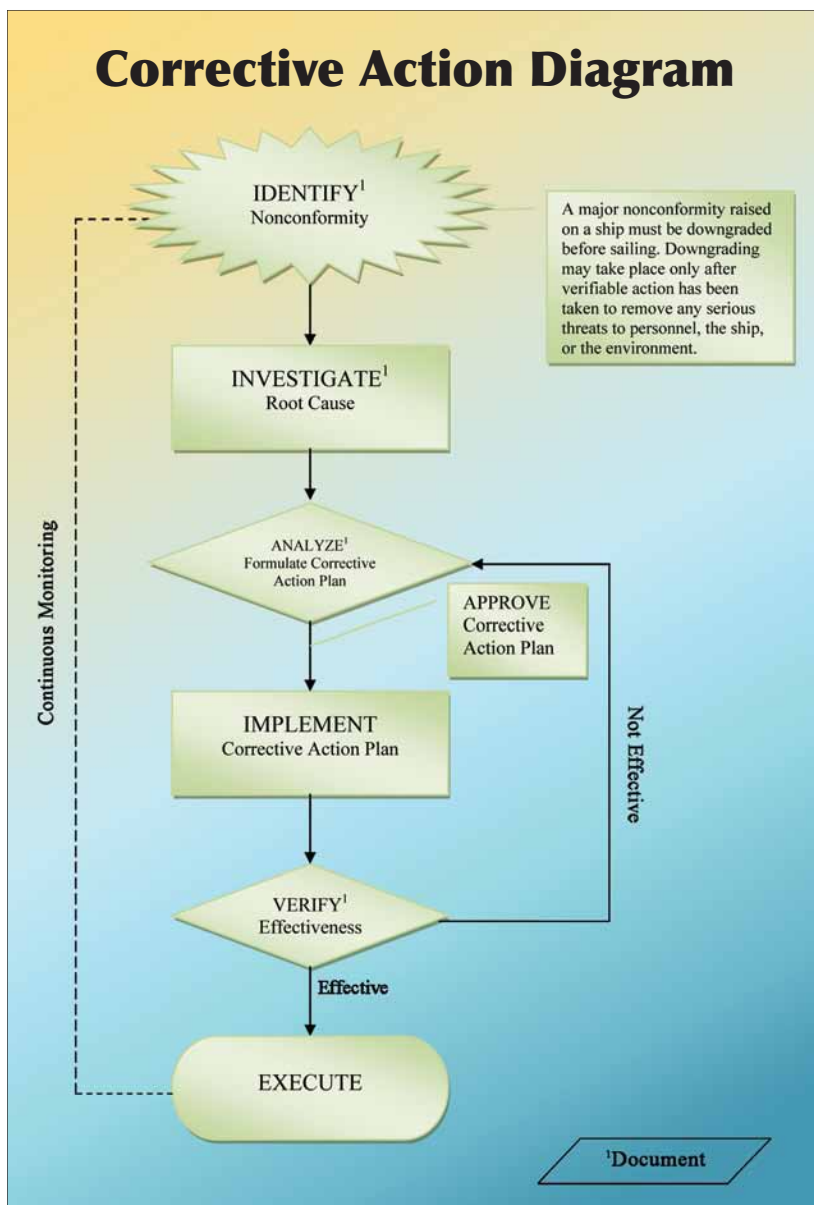
Over time, this methodology has matured and transcended industries such as civil aviation, rail transit, food safety, and health care. In the commercial maritime domain, compliance comes by way of an international mandate under Chapter IX of the International Convention for the Safety of Life at Sea (SOLAS) and the ISM Code, requiring shipping companies to each establish a management system to ensure that commercial vessels are maintained and operated safely, prevent maritime accidents, and protect the marine environment.

The guiding principles for a functional SMS can be summarized in three basic tenets:

- Say what you do.
- Do what you say you do.
- Prove that you do what you say you do.¹

A safety management system is a compilation of policies, procedures, and behaviors structured to ensure a formalized, proactive approach to safety management.

Corrective Action Diagram



the maritime company must ensure that the marine crew can rely on the functional process with full support from shore management. Likewise, shore management must depend upon the marine crew to employ the system to its full potential, setting forth the common goal of continual improvement.

Implementation

Despite the fundamental principles of the SMS methodology and regardless of the industry or mandate, all hinge on a single common premise—the management system is only as effective as its implementation. Implemented properly, a safety management system forms the functional framework for a comprehensive business management system designed to manage safety elements in the workplace.

In practice, an operational safety management system is the manifestation of the “prevention through people” ideology. However, if dismissed as a trivial requirement for certification, the SMS risks becoming just another catchphrase in the nautical lexicon, and such lack of effective implementation risks a substandard or materially unsafe condition.

Continuous Improvement

Safety assurance builds on the principle of continuous improvement by identifying and eliminating the root causes of substandard conditions. Companies can achieve this objective through ongoing operational SMS evaluations via internal company audits, management/master’s reviews, external verifications, and operational safety and corrective action monitoring.

This is simple enough, theoretically. Establishing management procedures and policies (*say what you do*) ensures that conditions, activities, and tasks affecting safety and environmental protection—ashore and aboard vessels—are planned, organized, executed, and checked in accordance with regulatory and company requirements. For many companies, this means formalizing long-established processes and placing the associated documents under a greater degree of control. For others, establishing an effective SMS is a more comprehensive process.

Conversely, putting the SMS into operation presents a dynamic challenge. Actually *doing* what you say you do requires an unconditional and unwavering investment from all levels of the organization, starting with the upper echelon of shore management and filtering down to the rank and file. For the safety management system to work as intended,

The guiding principles for a functional SMS:

- Say what you do.
- Do what you say you do.
- Prove that you do what you say you do.

If the corrective action doesn’t adequately address the actual root cause or underlying condition, then it will never be truly effective. In fact, it could be indicative of a flawed or ineffective system. In such cases, a flawed corrective action cycle is the navigational equivalent of dead reckoning.² Under this paradigm, as each estimate of position is relative to the previous one, errors are cumulative or compounding.

After all, a key indicator of a functioning SMS is not the absence of nonconformities, but rather a clear indication that when a nonconformance is identified, it is reported in accordance with the established procedure, analyzed, and that corrective action is undertaken in a timely manner (*prove that you do what you say you do*). This is the premise for effective continuous improvement.

Compliance

Today, compliance with the International Safety Management Code is associated with nearly every other aspect of overall regulatory compliance. The Coast Guard's oversight of the ISM Code is an element of safety assurance verification that occurs constantly as a part of many routine activities. Coast Guard personnel perform this oversight as the flag administration for U.S. vessels as well as under the Port State Control program for foreign vessels subject to U.S. jurisdiction. Examining a vessel for any purpose provides an opportunity to evaluate safety management system effectiveness. To leverage the maximum benefit of this approach, the Coast Guard has undertaken a review of existing code oversight policies with a view to rebooting the guidance to better focus field resources.³

The management system is only as effective as its implementation.

Vessel inspections and examinations provide a means of evaluating International Safety Management Code compliance, the most basic of which is verification that the vessel and company have valid ISM Code certification. The next step is to identify links between any deficiencies or casualties noted during the course of routine inspections/investigations and the vessel's SMS. This requires marine inspectors, port state control officers, and marine investigators to have a working knowledge of the ISM Code's key elements and the duties and training of shipboard personnel.

Although ISM Code oversight may not be the primary purpose of an examination, inspectors remain cognizant of the important role a safety management system has in mitigating deficiencies and preventing casualties. To this end, when conducting an inspection for purposes other than verifying compliance with the code, the inspector may note any deficiencies that most likely could have been discovered and managed if the SMS had been thoroughly applied. Oversight may also arise from investigations into vessel casualties and vessel crewmembers' reports.

As a flag administration, we focus on improving methods to identify poor-quality vessels to eliminate substandard

Noncompliance

Although safety management system indifference is generally the exception and not the rule, it is an unfortunate reality, nonetheless. That's why the Coast Guard initiated a campaign in 2011 focused on holding repeat offenders accountable by targeting the company SMS for increased oversight and compliance verification at the management level.

In a precedent-setting case, objective evidence of continued noncompliance with the requirements of the ISM Code, applicable international conventions, and flag state regulations — as well as a systemic failure to adequately implement company policies and procedures — led to the first-ever revocation and cancellation of a U.S. company's ISM document of compliance (DOC) for cause.

A review of attendance reports that various authorities, including port state control and the Coast Guard, documented clearly established a pattern of habitual disregard for rules and regulations. The company also repeatedly failed to implement effective corrective action, which was indicative of an ineffective SMS. Indeed, the company's DOC was on the third short-term issuance because of an ineffective response to externally raised nonconformances. As a result, the company's international fleet was essentially grounded due to the invalidation of required convention trading certificates (safety management certificates).

shipping. This means we take a more proactive role in administering the activities of recognized organizations, overseeing auditing and verification processes, and conducting trend analyses of possible SMS failures and major nonconformities on U.S. vessels. By monitoring potential failures and major nonconformities from a central view, the Coast Guard has been better able to identify trends indicating a systemic SMS issue across a common fleet management. Once the trends are identified, the Coast Guard can direct appropriate resources for focused oversight.

A key indicator of a functioning SMS is not the absence of nonconformities, but rather when a nonconformance is identified, it is reported and corrective action is taken.

The View From the Bow

Though it occurred almost 30 years ago, the *Herald of Free Enterprise* disaster remains a stark reminder of the consequences of untenable safety management practices. One goal of the International Safety Management Code is to establish a process of continuous communication, training, and actions that constantly maintain the vessel in a state of full compliance with safety and environmental protection regulations. This includes the processes and procedures for reporting accidents and nonconformities.

The ISM Code doesn't necessarily prescribe a manner in which this must be done. Rather, it allows companies to define their own ways of reaching that goal, taking into account the prescribed functional requirements for a safety management system. There is no one correct way to do this because an effective SMS is tailor-made to fit an individual company's culture, organization, service, and work environment. What may work for one company may not work for another.

Inspectors and auditors must therefore be vigilant to ensure companies have an effective safety management system that meets ISM Code objectives. An empty-husk SMS that only exists to satisfy what is viewed as "just another regulation" meets neither the spirit nor the intent of the code. A good measure of an effective SMS is one that allows users to identify, report, investigate, correct, and appropriately document nonconformities in accordance with the established procedure.

Inspectors and auditors ensure companies have an effective safety management system that meets ISM Code objectives.

A company's success level putting its SMS into operation is directly related to the organization's commitment to achieving those goals amidst all the other priorities competing for attention. Hence, strict discipline and a commitment to safety objectives starts at the senior management level. This requires a firm management and command structure with clear and concise orders. Leaders must pay attention to all matters affecting the safety of the vessel and those aboard and must regularly review performance against the organization's safety objectives.

While managers demonstrate commitment through their actions and involvement, all employees and crewmembers need to follow suit for the system to be fully functional and integrated. Accordingly, all employees and crewmembers should be aware of the influence their actions or inactions may have on SMS effectiveness. An effective safety management system starts with you—at the end of the watch, it's your vessel, your life, and your responsibility.

About the author:

LCDR Corydon Heard is the Prevention Department head at Marine Safety Unit Texas City. Prior tours include the U.S. Coast Guard Office of Commercial Vessel Compliance, Sector Baltimore, and Activities Europe. He is a graduate of the U.S. Merchant Marine Academy and has also earned an M.A. and a doctorate in business administration. He also holds an unlimited U.S. merchant marine officer endorsement.

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https://assets.digital.cabinet-office.gov.uk/media/54c1704ce5274a15b6000025/FormalInvestigation_HeraldoFreeEnterprise-MSA1894.pdf.

Safe Work Australia, Guide for Major Hazard Facilities: Safety Management Systems.

Endnotes:

- ¹ Marine Safety Manual Volume II, Section E, Chapter 3.
- ² Dead reckoning is the process of calculating current position by using a previously determined position, or fix, and advancing that position based upon estimated speeds over elapsed time and course. The resulting position is only an approximation, as it does not allow for the effect of significant errors.
- ³ This philosophy is maintained in Marine Safety Manual Volume II, Section E, Chapter 3. Key elements of this approach have been excerpted here.

Mitigating Risks on the Outer Continental Shelf

Safety and environmental management systems in action.

by LT JASON KLING

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The outer continental shelf (OCS) is one of the riskiest operating environments the U.S. Coast Guard regulates. Under the Outer Continental Shelf Lands Act, Coast Guard responsibilities include developing and implementing regulations to protect the safety of life, property, and the environment on outer continental shelf installations, vessels, and units engaged in OCS activities.

One of the most effective ways to mitigate safety and environmental risk on the OCS involves using safety and environmental management systems, often referred to as SEMS,¹ which provide a framework for using policies and procedures to adequately manage the risk associated with an offshore vessel or facility operation.

Like Nowhere Else

The OCS is a unique regulatory environment. It consists of oil and gas operators that the Bureau of Safety and Environmental Enforcement (BSEE) regulates, pipeline operators who answer to the Pipeline and Hazardous Material Safety Administration (PHMSA), contractors who aren't directly regulated, and vessel and facility operators the Coast Guard regulates.

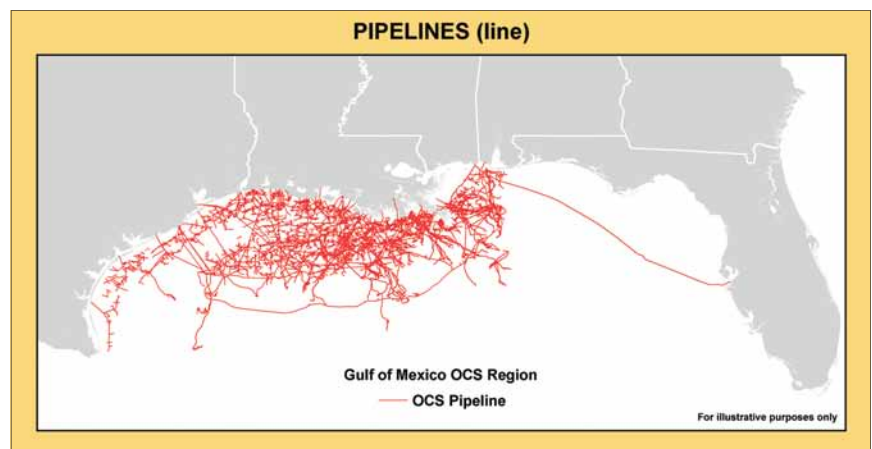
Oil and gas operators, also known as leaseholders, are in the business of exploring for, developing, and producing minerals on the outer continental shelf. These companies typically operate production facilities that may be fixed or floating platforms. While the leaseholders are physically present and responsible, they normally hire drilling contractors who operate mobile offshore drilling units (MODUs). OCS oil and gas operators must maintain safety and

environmental management systems to manage the risks associated with these operations.

Regulatory Challenges

The BSEE regulations in Title 30 Code of Federal Regulations, Part 250, Subpart S, incorporate the American Petroleum Institute Recommended Practice 75 for developing, implementing, and maintaining safety and environmental management systems. BSEE supplements this recommended practice with additional SEMS program features and an audit protocol with agency oversight. The BSEE SEMS rule was published in 2010,² updated in 2013,³ and has been an effective tool used by oil and gas operators to manage risks and coordinate with contractors.

Pipeline operators transport oil and gas to onshore facilities and install and maintain subsea pipelines that make up the complex network that runs under the Gulf of Mexico. The pipelines connect BSEE-regulated offshore facilities to



The Gulf of Mexico outer continental shelf pipeline network. Photo courtesy of the U.S. Department of Interior, Bureau of Ocean Energy Management.



View of a floating offshore installation from a vessel at the 500-meter zone boundary. U.S. Coast Guard photo by LT Jason Kling.

onshore facilities that may be Coast Guard-regulated, so the operators have a variety of interfaces that each present a certain degree of risk. Additionally, pipeline operators significantly contribute to the OCS risk profile that correlates to the amount of pipeline mileage spanning the seabed. The Pipeline and Hazardous Material Safety Administration is developing a national consensus standard for pipeline safety and environmental management systems. By adopting the API Recommended Practice 1173, PHMSA plans to provide its operators with the framework needed to manage the risks inherent in large-scale oil and gas transportation.

Vessel operators provide mobile capabilities for the above-mentioned operators, and are contracted to carry out a variety of outer continental shelf activities. Vessels are typically involved in offshore facility construction, while MODUs perform drilling activities. Vessels also provide support services for facilities engaged in exploration or production processes. This extensive support of offshore infrastructure increases vessel OCS exposure, which increases the risk from offshore activities.

Safety Management Systems

While the Coast Guard does not have safety management regulations specific to vessels engaged in OCS activities, it does require safety management systems on certain vessels engaged on a foreign voyage. Title 33 CFR Part 96 contains these regulations that generally apply to a foreign voyage vessel that:

- transports more than 12 passengers;
- is a tanker, bulk freight vessel, freight vessel, or self-propelled mobile offshore drilling unit of 500 gross tons or more; or

- is a foreign vessel bound for ports or places under the jurisdiction of the United States and subject to Chapter IX of the International Convention for the Safety of Life at Sea (SOLAS).

While this regulation may apply to vessels engaged in OCS activities, many vessels in dedicated offshore service do not operate under a regulated SMS or SEMS. In 2013, the Coast Guard published an Advance Notice of Proposed Rulemaking to communicate the agency's intentions to require SEMS on vessels engaged in OCS activities.⁴ The rulemaking project is currently under development to evaluate the need for additional safety and environmental management system requirements for OCS vessel operators.

Bridging the Gap

While leaseholders, pipeline operators, and vessel operators perform routine activities associated with their facilities, they may also rely on offshore service contractors to carry out specialized activities. This additional group is not directly regulated, but is usually involved with many of the activities associated with exploration and production processes.

Placing all of these parties on the outer continental shelf makes for a complicated interface. To better manage communications and risk, the oil and gas operators exercise a bridging process to align safety policies and procedures. Since leaseholders are responsible for all work executed under their lease, they rely on their SEMS to guide their operators and contractors as they perform safety and environmental activities.

The bridging process involves a meeting between management personnel of each operator to align their safety and environmental management systems. In cases where an operator does not have a safety and environmental management system, the companies' safe work practices are used instead. Often, the operator the leaseholder contracts adopts the SEMS of that leaseholder as its guiding system for safety management during the contracted work period. In all cases, all contracted work between parties on the OCS is completed after signing a bridging agreement.

Additional Players, Additional Risk

There is a characteristic of the bridging process that presents an added element of risk to OCS operations. Although company management agrees upon the safety and environmental protection measures to be followed during the contract period, the operational interface exists between persons in charge of the facilities or vessels, and these people are not always involved in the bridging process. To reduce the risk of human error due to procedural misunderstanding,

the bridging relationship should be more aligned with the working relationship.

Subcontracting also separates the leaseholder from some of the operators working on its lease. For example, an oil and gas company hires a contractor to perform dive operations at its facility, and that contractor then contracts a vessel operator to remain on station for those activities. While the production facility may have a bridging agreement with the dive contractor, it may not have a bridging agreement with the vessel that is station-keeping next to the facility. This complicates the safety relationship.

Further, although the bridging process between parties helps to mitigate the risk for safety and environmental incidents, the operational scheme at an offshore lease site can be extremely complex. An offshore facility typically utilizes multiple vessels for operational or support services. One industry norm is to have vessels maintain distance beyond 500 meters from the facility to reduce risk until vessel services are actively needed. When facility/vessel interface is required, the vessels will proceed inside the 500-meter zone under the direction of the leaseholder.

While the master controls the condition and safety of the vessel, the facility (leaseholder) directs its movements. Risk is elevated when vessels are in close proximity to offshore facilities where the transfer of personnel, bulk liquids, or equipment takes place. While safety procedures aim to control the risk associated with common offshore activity, multiple players are involved and rely upon each other to safely complete the evolution.

An environment that has a variety of parties, each with their own degree of responsibility over the operations, may provide a false sense of safety over the entire operation. The leaseholder is rigidly accountable to all its contractors to ensure they're following the appropriate safe work practices. All operators and contractors are confident that every person on the job is following the procedures and is responsible for safety in their work area. This perception may remove a sense of vulnerability among the workers at the lease site, prompting them to let down their guard regarding potential hazards around them.

While safety and environmental management systems introduce more procedures to control the probability of human error, they must be backed up by a safety culture that influences crew attitudes and perceptions. Crew participation and ownership of the SEMS is an effective way to improve understanding of the capabilities and limitations of



Coast Guard personnel observe dynamic positioning operations on an offshore service vessel. U.S. Coast Guard photo courtesy of LT Jason Kling.

the system's policies and procedures. The offshore lease site may have multiple active safety and environmental management systems and bridging agreements, so it's critical that workers, in addition to safety managers, understand the appropriate procedures to be followed.

Additionally, the leaseholder is responsible for all activities at the lease site and should ensure that the safety culture of each contractor facilitates realistic perceptions of the state of offshore safety. Safety performance indicates that offshore operators have been effectively managing the risk of safety and environmental accidents with SEMS, but that doesn't mean the risk isn't present. The risk is *always* present, and operators, contractors, and regulators must be vigilant to continue to properly utilize safety and environmental management systems to prevent safety and environmental incidents on the outer continental shelf.

About the author:

LT Jason Kling recently transferred to the Marine Safety Center from the Office of Design and Engineering Standards. He graduated from the U.S. Coast Guard Academy in 2005 and the University of Maryland Clark School of Engineering in 2013. His tours include Sector New York and Sector Mobile.

Endnotes:

- ¹ Safety Management Systems (SMS) is the term used by the marine industry, while Safety and Environmental Management Systems (SEMS) is the term used by the offshore industry. The two terms represent the same concept of a system of policies and procedures used to manage safety and environmental risks associated with work activities.
- ² 75 FR 63610, "Oil and Gas and Sulphur Operations in the Outer Continental Shelf—Safety and Environmental Management Systems."
- ³ 78 FR 20423, "Oil and Gas and Sulphur Operations in the Outer Continental Shelf—Revisions to Safety and Environmental Management Systems."
- ⁴ 78 FR 55230, "Safety and Environmental Management System Requirements for Vessels on the U.S. Outer Continental Shelf."

Creating an Effective Safety and Environmental Management System for Offshore Oil and Gas Operations

Adopting performance-based requirements into a hybrid regulatory regime.

by MR. STANISLAUS KACZMAREK, P.E.

SEMS Section Chief

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The Bureau of Safety and Environmental Enforcement (BSEE) within the U.S. Department of the Interior develops, administers, and enforces regulatory programs to ensure that lessees, operators, and their contractors conduct safe and environmentally sound operations during exploration and development of our nation's oil, gas, and renewable energy resources on the outer continental shelf (OCS).

BSEE's major functions include:

- developing safety and environmental regulations,
- evaluating industry standards,
- permitting,
- facility inspections,
- investigating incidents and equipment failures,
- research,
- safety and environmental enforcement, and
- promoting performance-based safety and environmental management systems (SEMS).

SEMS is a key initiative, in which the Bureau of Safety and Environmental Enforcement requires adopting internal processes and work practices to facilitate and effectively manage safety and environmental hazards encountered during OCS activities. The driving force behind SEMS is a belief that safety and environmental management effectiveness will grow from an improved awareness of the safety and environmental hazards confronted by the workforce.

Effectiveness will also grow when workers are provided a say in how to best mitigate the recognized hazards in the context of their operations, an ability to measure the success of risk management via performance indicators, and a willingness to continually learn from past experiences so that risks may be eliminated or mitigated during future evolutions.

As compared with BSEE's historical regulatory approaches, SEMS further introduces an acceptance of flexibility in how performance is measured and how it is achieved, allowing the operator to design a program that will work within the organization and management culture.

A Hybrid Approach to Regulation

One aim of BSEE's approach to safety and environmental management system enforcement is to provide lessees and operators the flexibility to implement a performance-based management system that works in their cultures while still requiring them to continue to adhere to all of BSEE's prescriptive and other performance-based requirements.¹ In many ways, SEMS builds upon the foundation of prescriptive regulations and established industry standards.

The bureau's regulatory requirements define a baseline of technologies and safety and environmental barriers that operators must install, maintain, test, and use in oil and gas work on the OCS. These regulations include a variety

of prescriptive and performance-based requirements that address specific equipment or operations, including specific requirements for drilling (Subpart D of BSEE regulations — 30 CFR 250), well completion (Subpart E), well workover (Subpart F), well control (Subpart O), and decommissioning (Subpart Q). Additional requirements address production safety (Subpart H), the safe design and operation of platforms and structures (Subpart I), and pipelines (Subpart J).

The SEMS regulations (Subpart S) build on these requirements by specifying that companies must manage the human interfaces and interactions required to operate on the outer continental shelf and to handle the complexity of information flow in oil and gas work to ensure safe operations. A fundamental principle of SEMS is that operators assess and evaluate all hazards associated with their operations, then work to eliminate or mitigate the unacceptable risks associated with those hazards.

Detailed regulations focusing on specific pieces of equipment or specific tasks are often not broad enough to ensure safe operations in every possible scenario. Safety and environmental management systems, on the other hand, guide operators to look at the big picture, taking into account how activities or changes in one area may impact safety and environmental aspects of operations in another.

Detailed equipment-related regulations addressing specific issues may take years to develop and promulgate. A performance-based regulation such as SEMS allows the regulator to focus on broader safety objectives and the mitigation of risks. This gives industry the flexibility and responsibility to determine the best way to achieve such objectives without waiting for new regulatory requirements.

Adding SEMS requirements into the BSEE program is a clear indication that the bureau is moving toward adopting more performance-based requirements into its existing hybrid regulatory regime.

Challenges in Adopting Performance-Based Regulations

The industry view toward adding a performance-based requirement (i.e. SEMS) to the OCS regulatory program was mixed. Early on, some of the regulated community approached the SEMS requirements as a mandate to write a series of procedures as outlined in the regulations, and then show them to the regulator whenever asked. Auditors were also hesitant to share their observations, whether they were areas of excellence or weakness in the management system approaches. The emphasis appeared to be on documenting compliance instead of assessing performance.

SEMS Compliance Requirements	
1.	A safety and environmental management system (SEMS) has been defined.
2.	It addresses all provisions of 30 CFR 250, Subpart S.
3.	There is evidence of ongoing attempts to implement it in the field.
4.	An independent and accredited third party audits it at least once every three years.
5.	The associated SEMS audit plans, SEMS audit reports, and corrective action plans are submitted to BSEE within the timeframes listed in Subpart S.

From BSEE's perspective, we needed to establish alternate approaches to enforcement, looking at the overall commitment and application of a management system approach rather than looking at each activity within the management system as a compliance vs. nonconformance opportunity. Thus, the Bureau of Safety and Environmental Enforcement made the decision *not* to issue incidents of noncompliance for deficiencies identified through a safety and environmental management systems audit unless the overall conclusion was that the management system did not really exist.

To further demonstrate our commitment to viewing safety and environmental management systems differently than the way we enforce our other regulatory requirements, the bureau lists a limited number of items by which SEMS compliance can currently be assessed (see table above).

By focusing solely on compliance during a safety and environmental management system audit rather than assessing system effectiveness, the auditee creates a barrier to achieving the full potential of SEMS. An excessive focus on compliance with specific requirements can also create a false sense of safety within the workforce, as individuals may assume that everyone is following the same procedures and standards, and that they are all effective.

The Bureau of Safety and Environmental Enforcement, building on its enforcement foundation, also needed to view safety and environmental management systems differently, shifting from inspecting for compliance to inspecting for safety. For the most part, BSEE compliance expectations for SEMS largely deal with creating, rolling out, and maintaining a SEMS program. If there is evidence of a demonstrated, ongoing commitment to find and fix weaknesses in the management system, then the bureau will support those commitments.

Safety and Environmental Management System Regulations

SEMS regulations required that operators and lessees design and implement an outer continental shelf management system by November 2011. The components of that management system were based in large part on an American Petroleum Institute Recommended Practice for a Safety and Environmental Management Program (API RP 75) last updated in 2004.

Both the Bureau of Safety and Environmental Enforcement regulation and API RP 75 defined those management system components as:

- management responsibilities and practices,
- safety and environmental information,
- hazard assessment,
- change management,
- operating procedures,
- safe work practices,
- training,
- quality assurance and mechanical integrity,
- pre-startup review,
- emergency response,
- incident investigation,
- auditing, and
- records management.

Then, in 2013, the Bureau of Safety and Environmental Enforcement proposed additional requirements beyond those contained in API RP 75 for each operator's or lessee's safety and environmental management system. These proposals became requirements in 2014 and 2015 and included:

- establishing stop work authority,
- naming an ultimate work authority,
- formalizing an employee participation program,

- reporting unsafe working conditions,
- enhancing job safety analyses through review and signature by all workers and management involved in a job task, and
- accreditation for lead auditors performing the SEMS audits called for in the regulation.

Through conversations with offshore industry representatives and other stakeholders, BSEE is currently exploring whether additional or alternate approaches are needed to enforce the SEMS regulations or if revisions to API RP 75 are desired so that the performance-based aspects of the regulation can be further strengthened.

The focus of these inquiries surrounds the best ways to close perceived gaps in the following areas:

- contractor SEMS (BSEE is currently requiring only operators and/or lessees to implement 30 CFR Part 250, Subpart S);
- risk assessment methodologies (the current regulations do not specify how the hazard assessment is to be used to mitigate risks);
- human factors (the current regulations do not specify what types of human factor considerations are essential to growing a safety culture);
- performance indicators (though SEMS is a performance-based regulation, there is little attention as to how to measure performance); and
- SEMS auditing requirements (the content of audit reports needs to be improved to ensure that the effectiveness of the programs and audits can be measured).

BSEE is working with the API committee that is responsible for RP 75 as well as the Offshore Energy Safety Institute to identify and frame any opportunity for making SEMS both a more effective regulation and a widely adopted standard practice.

How BSEE Assesses SEMS Success

Further, the Bureau of Safety and Environmental Enforcement works with stakeholders to determine and document what effectiveness and performance in the safety and environmental management system elements look like, and how they can be measured. For example, the bureau uses information from several sources to assess whether individual operators use safety and environmental management systems effectively, including feedback from BSEE's inspectors, incident investigations, audit plans, audit reports, and corrective action plans that regulations require be submitted to BSEE.

Companies can demonstrate a commitment to use safety and environmental management systems to drive safe behaviors and continual improvement in safety and environmental performance by providing evidence regarding which aspects of the management system are working and which are not, and then demonstrating that steps to close those gaps have been identified and are being implemented.

The Bureau of Safety and Environmental Enforcement also sponsors research to define quantifiable, SEMS-appropriate key performance indicators for individual operators, which it will share with industry. Eventually, if industry accepts

and adopts these or similar performance indicators, they will provide an indication not only as to whether safety and environmental management systems influence OCS behaviors, but also if change in those behaviors is making a measurable difference.

Finally, BSEE will assess if SEMS effectively guides better safety and environmental performance throughout the oil and gas OCS industry by monitoring and promoting the sharing of information on risk areas and best practices with the rest of industry.

To assist industry in this regard, the bureau has partnered with the Bureau of Transportation Statistics (BTS) to set up a near-miss reporting system. BTS is one of the 13 principal statistical agencies Congress authorized under the Confidential Information Protection and Statistical Efficiency Act to collect and handle information in ways that protect the confidential and proprietary nature of such information and their sources while still using it to provide actionable intelligence for others in the industry. Reports can be made in confidence at www.SafeOCS.gov or by calling 1-844-OCS-FRST (1-844-627-3778).

Auditing

The audit report is the main source of detailed information BSEE receives on what's working in the safety and environmental management system and what is not. The bureau's SEMS regulations require that lessees and operators receive a third-party-led audit of their management system every three years, and that this triennial audit sample the effectiveness of the management system in controlling safety and environmental risks on 15 percent of each operator's OCS facilities.

When SEMS was first put into effect, the audit reports BSEE received focused more on statements of compliance rather than on evidence of effectiveness. While it's easy to have a documented management system that contains verbiage referenced in a regulation, it is much more difficult to define and test a system that management willingly supports, promotes, and actually empowers all workers to think and participate in safety and environmental protection, and is subsequently used in disciplined ways every day.

One way to ensure the audit reports provide better value to the operator and to BSEE is to create and enforce standards on how an audit should be conducted and reported. To support this, the Bureau of Safety and Environmental Enforcement requires that accredited auditors lead each SEMS audit, working with the Center for Offshore Safety,² to change the way lessees and operators approach these third-party-led audits.

Just as an effective safety and environmental management system must be based on knowledge of the hazards that need to be managed, BSEE is working with the Center for Offshore Safety to adopt a systematic approach to auditing in which specific, observed hazards in a facility or in an operation become the starting point for exploring how (or if) the management system has recognized the hazards, mitigated the risks, and improved the risk controls over time. This approach will give the audit team an opportunity to evaluate whether the elements of the management system are integrated into the full operating process.

Furthermore, audit service providers are being asked to try to begin the assessment of possible root causes for any findings to determine if an observation reflects a random occurrence or a more systemic issue. Both scenarios pose different risks to the safety of operations, and such an assessment can guide the operator to adopt the appropriate mitigation steps to prevent a recurrence.

The bureau's current regulations require that reports summarizing the SEMS audit be submitted to BSEE and that they highlight the audit team's findings, observations, and conclusions, identifying deficiencies. This then enables BSEE to fulfill its regulatory obligation to determine if the associated corrective action plan proposed by the lessee or operator will be effective in closing the gaps and improving the ability of the management system to control risks.

To help in this regard, the bureau is also working with the Center for Offshore Safety to create a more detailed definition of the evidence that should be provided in an audit report. By providing guidance on what should be included in a safety and environmental management system audit report, BSEE anticipates receiving a more representative assessment of OCS operator safety performance than has been provided in the past.

Continual Improvement

A recurring theme in all management systems, and in BSEE's approach to SEMS, is the belief that an effective management system must be continually tested and quickly improved every time it is found to be weak in 1) recognizing hazards that exist, or 2) in empowering every person who faces those hazards with the knowledge, protocols, equipment, and support they need to control them. As we learn more, we will consider modifying our approaches or employing more of the tools at our disposal.

The bureau's approach to SEMS promotion can be summarized as follows:

- Learn from operators who have a robust safety and environmental management system by focusing on what is

working well in their management system implementation and helping such operators inform and promote consideration of those activities they have found to be particularly important in managing risks.

- Ensure that when operators commit to corrective actions in response to SEMS audits, that these actions address not only the specific deficiency identified by the auditor but also the underlying systematic weaknesses contributing to the deficiency. In some instances, a corrective action may require that changes to the safety and environmental management system design or implementation be made across an operator's full network of facilities.

Along these lines, BSEE hopes to engage operators in deeper dialogue regarding the creation and management of their corrective action plans. For example, the Bureau of Safety and Environmental Enforcement may request that company investigators looking into specific incidents, near-misses, or gaps found by their auditors dig deeper to identify and fix the technical and human root causes rather than just the more obvious symptoms.

In cases where BSEE becomes concerned about the effectiveness of an operator's management system, perhaps due to recurring or severe incidents, the bureau may require a company to perform a directed audit outside of the normal three-year schedule to identify potential shortfalls and provide the operator with additional knowledge on where their systems may require improvement.

The bureau may conduct its own investigations into the robustness and effectiveness of one or more of the operator's safety and environmental management system elements, requiring the findings to be acted upon. Normally this action is taken when a new operator comes into the field or when there are specific, focused concerns that BSEE inspectors have raised.

For those operators who do not have a functioning safety and environmental management system, BSEE can require the lessee or operator to cease operations until they can demonstrate they have a SEMS in place, and that it plays an important role in day-to-day operations.

About the author:

Mr. Stan Kaczmarek has a B.S. degree from the State University of New York and an M.S. degree from Cornell University. His experience includes engineering environmental controls in the oil industry; creating standards; developing audit programs to improve health, safety, and environmental risk management in multinational corporations; and participating on incident management teams and auditing oil spill response in the U.S. and abroad. His role at the Bureau of Safety and Environmental Enforcement is to help improve the effectiveness of safety and environmental management systems as a risk management tool.

Endnotes:

- ¹ Prescriptive regulations specify what to do, and sometimes how to do it. Performance-based regulations specify performance criteria and leave it to the regulated party as to how best to achieve it.
- ² In June 2015, BSEE named the Center for Offshore Safety an official audit service provider accreditation body.

ISM Code and Vessel Safety Management Systems

Reading between the lines to optimize compliance.

by MR. JASON M. YETS
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All passenger ships, regardless of tonnage, must comply with the International Safety Management (ISM) Code, enforced through the International Convention for the Safety of Life at Sea (SOLAS). As required by the code, these passenger ships must employ a safety management system (SMS).

A typical cruise ship safety management system is an incredibly large, multi-layered system consisting of thick volumes of books and manuals—or, more commonly, computer-based references. It encompasses all the rules, regulations, policies, processes, and procedures a company and ship employ to make sure everyone uses the same rulebook to ensure consistency.

First, a company designs, develops, and implements its SMS. Then its flag administration¹ or an organization the administration recognizes (commonly referred to as the “recognized organization,” or RO) approves it and issues a safety management certificate (for the ship) and a document of compliance (for the company).

Shipboard personnel play an integral role in SMS self-management. If a policy, procedure, or form is not being followed, or in practicality does not work on the vessel for which it was developed, the crewmember must use the defined lines of communication established within the safety management system to report such shortcomings.

Audits

The company undergoes required internal audits every 12 months to ensure compliance during the certificate’s validity. Members of the company’s shoreside personnel generally conduct these audits so that the examined areas are reviewed by someone not associated with them.

The administration, either directly or through a recognized organization, also performs a thorough examination of the vessel annually. During this time, auditors identify if the vessel is working within the confines of the safety management system.

Lastly, port states² have a vested interest in vessels that call on their ports and navigate in their waters. The U.S. Coast Guard (USCG) examines each foreign-flagged cruise ship through its foreign passenger vessel exam program at least twice per year. Though port state control officers (PSCOs) mainly examine the vessel for substantial compliance with federal law and international regulation, this exam is not limited to those groups of rules. USCG PSCOs will also verify that the vessel is being operated in accordance with the company’s safety management system.



A ship's officer explains safety management system testing procedures to USCG examiners. All photos courtesy of the Cruise Ship National Center of Expertise.



Ship emergency teams discuss safety management system procedures with USCG examiners after a fire drill.



Students learn how to evaluate ships' safety management systems as part of the Foreign Passenger Vessel Examiners Course.

Compliance

Let's look at how USCG PSCOs use a ship's SMS to evaluate and enforce compliance. First of all, identifying the way a ship "lives" is the key to understanding a ship's safety management system and its relation to the ISM Code. Beyond examining the required paperwork to ensure all the "i's are dotted and the "t's crossed, it's equally important—if not more so—to see how the crew manages the vessel according to the SMS.

Example 1—Fire Drill Anomaly: A port state control officer notices that none of the firefighters have an air cylinder attached to the breathing apparatus during a fire and abandon-ship drill. The PSCO immediately identifies a possible deficiency against Chapter III of SOLAS. Any port state control officer knows that SOLAS requires drills to be performed in a realistic manner, but the absence of this cylinder makes the drill unrealistic, as a firefighter would never go into a fire without an air source.

Further into the exam, the port state control officer learns that the company recently implemented a new policy into the SMS. As a result of a recent accident on a sister ship, the company decided that using charged air cylinders during drills was an unnecessary risk until all the cylinders could be tested. The regulations note that a drill should be "as realistic as possible," and the company did, indeed, deem it as realistic as possible without incorporating an unnecessary, identified risk. Since the company still uses these cylinders during regular controlled training to ensure crew proficiency, the PSCO should have no concern.

There can be a fine line in making such judgment calls. Though there was no cause for concern in the previous example, one must read the SMS carefully for each situation. For example, if the ship's SMS stated that all firefighters were to have fully operational equipment during fire drills and they had to breathe air from the cylinder to promote realism, then the same situation would constitute a violation of the ship's procedures. By extension, it would also constitute a nonconformity with the requirements of their safety management certificate.

Example 2—Ship's Systems: During an exam of engineering spaces, the PSCO notes that a secondary oil content meter (OCM), commonly referred to as the "white box," isn't operating. There's no regulatory requirement for this secondary system, but it *is* required according to the ship's SMS. Even though neither domestic nor international regulations apply, established company policy, approved by the vessel's flag state, provides for nonconformance with the requirements of the safety management certificate.

Example 3—The Human Factor: During vessel walk-through, the port state control officer notices that tables and chairs block an emergency escape route. The shipboard officer notes they're stored there because they have no more storage space available. The PSCO makes note of this deficiency, and later, when he or she reports this finding to the lead examiner, it's identified that the vessel was issued the same deficiency, in the same location, with the same tables and chairs, for the last three exams. While it's obviously a problem that the tables and chairs are stored there, the bigger problem lies in that the issue is recurring, with no corrective actions taken to rectify the identified nonconformity.

In Practice

These three scenarios show that when the PSCO identifies a nonconformity with the ship's SMS, understanding writing the deficiency to the ISM Code is important. The code itself must be cited, but not without regulation to support it; SOLAS Chapter IX/3 is the supporting regulation, making compliance with the code mandatory. Lastly, the PSCO must identify the element of the ISM Code that best describes the standard the vessel is unable to or has failed to meet.

Safety management systems, more often than not, are far more stringent than any domestic or international law, as it is in the company's best interest to protect their personnel and assets. For example, some companies require each lifeboat to be lowered to the water once a month, whereas international regulation only requires this once every three months.

Remember, we are writing requirements based on each vessel's system and their company's interpretation of the system—not ours. When we identify issues where a ship's crewmembers aren't complying with their own company's requirements, we should expand our exam to ensure it's an isolated incident—not systemic. We can also call for the vessel's flag state to conduct an external audit to bring additional attention to a noncompliant condition. As a PSCO, this is the end-goal: to correct issues that create unsafe conditions, ensuring a vessel is in substantial compliance.³

Recording Deficiencies

Writing deficiencies to a ship's SMS by way of the ISM Code can be confusing, as the code incorporates some vague verbiage, so port state control officers must ensure they are directly correlating the deficiency identified to the corresponding section of the code.

The IMO has developed guidelines to assist companies in establishing routine maintenance intervals for shipboard systems. When using these guidelines, remember they are just that—guidelines, not requirements. The specific intervals for system maintenance are listed in the ship's safety management system. These intervals are what the company and flag state have agreed to, and thus can be held to, unless the administration approves otherwise.

Let's review the previous examples and identify the best possible method to record deficiencies:

Example 1—Fire Drill Anomaly: The firefighters lacked an air cylinder during the fire drill, but the company SMS

identified the reason for this deviation from “realistic,” so there is no problem and no deficiency should be recorded. However, if the SMS stated that all firefighters must breathe air from the cylinder, but they didn't, then PSCOs should record this requirement, following it with the identified deficiency.

Example 2—Ship's Systems: The secondary OCM, or “white box,” was not functioning. Although regulation doesn't require this, the company's safety management system does. Part A of the ISM Code, 1.2.2.2, requires that the company assess all identified risks to the environment and establish appropriate safeguards. In this instance, the company established the risk of accidental discharge, implemented a secondary OCM, and it was discovered to be non-functioning. This again shows that what the policy states should be functioning is not actually functioning “as the ship lives.”

Example 3—The Human Factor: The same deficiency is identified during each of four concurrent exams. Part A of the ISM Code, 9.2, requires the company to establish procedures to implement corrective action, including measures to prevent recurrence. There are two ways to look at this, starting with where the breakdown occurred—whether it was within the SMS, or whether it was a shipboard personnel issue. If the requirements of Section 9.2 aren't met due to a lack of policy or procedure, then it's a clear nonconformity with the ISM Code. If it's a personnel issue, then we refer again to 9.2 and further support it with SOLAS Chapter XI/4.

The examples given above are just that. The examiner's goal is to find the best cite that most accurately correlates to the finding and best supports the deficiency. The Cruise Ship National Center of Expertise stands ready to assist you, and we can also provide any ISM-specific training needed.

About the author:

Mr. Yets joined the Cruise Ship National Center of Expertise in 2011 following a shipboard career with a major cruise line, where he was a safety officer. He is a marine inspector and instructor for the Cruise Ship National Center of Expertise, manages its basic foreign passenger vessel examination training program, and serves as the unit's public affairs officer.

Endnotes:

- ¹ Administration is defined as “... the government of the state whose flag the ship is entitled to fly.” ISM Code, 2010 edition.
- ² A ship is entitled to fly a designated state flag. When that ship enters the waters of any other state flag during its voyage, that ship is entering a “port state.”
- ³ Requests for external audits by the flag administration should be noted and formally requested on the Form B. Navigation and Vessel Inspection Circular, 04-05, “Port State Control Guidelines for the Enforcement of Management for the Safe Operation of Ships (ISM Code)” can also provide additional guidance.

Strengthening Our Foundation

Fostering an even more robust safety culture within the liquefied gas industry.

by CDR JASON SMITH
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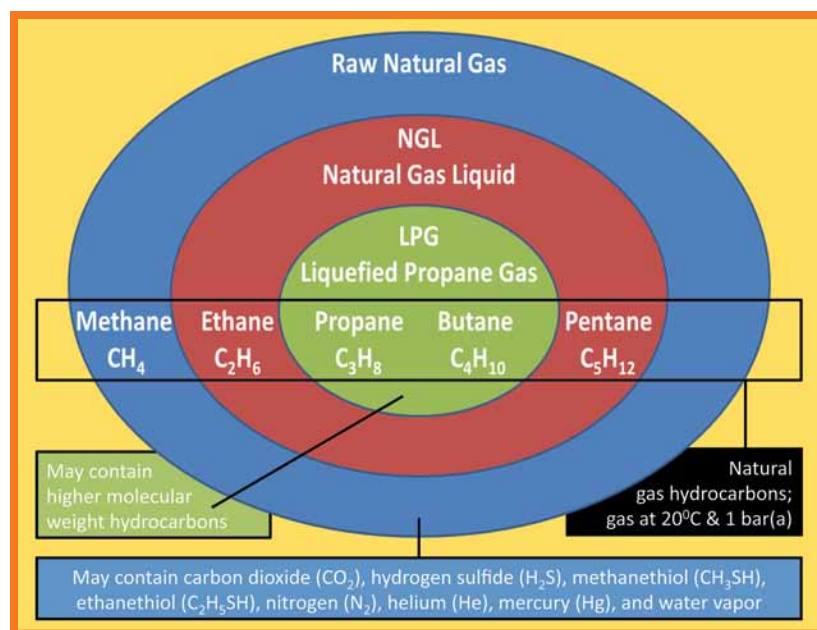
For more than a half century, the maritime community has been safely transporting liquefied gases over the water throughout the world, providing clean-burning fuel and feedstock to industrialized and developing regions of the globe. Because of the unique properties and hazards associated with liquefied gases, safety at all stages is paramount.

Safety First

It is this mindset across the industry that has allowed it to maintain such an excellent safety record throughout its more than 50-year history. Much like the key goal of a safety management system (SMS), the liquefied gas community—including regulators, independent standards organizations, trade organizations, and, most importantly, the industry itself—all seek to maintain an across-the-board

safety culture to address the inherent dangers of this industry as well as the potential for human error and omissions.

This safety-focused concept was not new to the liquefied gas industry during the late 1990s and early 2000s, when the International Safety Management (ISM) Code and similar U.S. domestic requirements were implemented, requiring safety management systems for all types of deep-draft international vessels and some domestic ships. Commitment from top management, cargo operational and emergency procedures, and regular process reviews on liquefied gas carriers were put into place decades earlier—some even dating back to the principal concepts established in the 1950s by the pioneers of the industry's first purpose-built liquefied gas carriers—that have been maintained ever since.



So why did this industry focus so strongly on safety to achieve an across-the-board “gold standard” from the start? This question can be answered by understanding what a liquefied gas cargo is, the unique hazards associated with it, and the public’s concern for the perceived risks these hazards pose on the water.

According to the International Maritime Organization (IMO), a liquefied gas is a gaseous substance at ambient temperature and pressure, but liquefied by pressurization, refrigeration, or a combination of both.¹ The principal liquefied gas cargoes include liquefied natural gas (LNG), liquefied petroleum gas (LPG), liquefied ethylene gas, and a variety of petrochemical gases. Each type of liquefied gas has specific hazards, some that are common with other hydrocarbons and some that are unique to themselves and/or other liquefied gases.

Figure 1: The primary components of raw natural gas, and how the different types of natural gas are utilized in the marketplace. U.S. Coast Guard graphic.

Steady State

Surprisingly, most liquefied gases are not hazardous, explosive, or environmentally damaging to the water or ground when spilled, but each does contain some unique safety risks that must be acknowledged and addressed. One of the most common challenges with liquefied gases is that they are, by nature, a live cargo—a liquid that wants to be a gas. Therefore, equipment and systems must be put into place to prevent this.

To keep it in its liquid state, liquefied gas must be under some combination of pressurization and/or refrigeration. When under pressure, the tanks that store the liquid must be designed to withstand a large-volume, high-pressure load. When refrigerated, the tanks must be designed to keep the liquid well insulated. In some cases, the cargo is so cold that the tanks and other systems that come into contact with the cargo must use specialized materials to withstand cryogenic temperatures.

Additionally, since almost all liquefied gases are hydrocarbons, they are flammable in nature, which is the characteristic that makes hydrocarbons so valuable. Because of this, measures must be taken to keep hazardous areas safe from ignition sources, monitored for leaks or fire, and protected if a release or fire occurs.

The Record

Despite the unique hazards associated with transporting liquefied gas and the public perception of liquefied gas carriers, accidents related to gas carrier cargoes have been few, and the safety record of liquefied gas carriers is an acknowledged industry leader. That so few incidents have occurred demonstrates the success of the industry's safety culture.

One case in point is the *Gaz Fountain*, a liquefied natural gas tanker that was hit by three maverick missiles in 1984 during the first Gulf War while carrying a partial load of LPG. Even though several fires penetrated the containment system, they were successfully extinguished. The ship and most of the cargo were salvaged.²

Another example was considered the worst grounding accident of a loaded liquefied gas carrier. The fully loaded LNG carrier *Paul Kayser* ran aground in 1979 off the coast of Gibraltar.³ Despite significant bottom damage over the

The Regulations

Some of these safety culture concepts were first introduced by the pioneers of the industry, and over time they have been improved, expanded, and formalized by international and government regulations, industry standards, and company policies. In addition to the International Safety Management (ISM) Code, three international codes specifically written for liquefied gas carriers all address the need for some type of operational procedure. Even the first international code for liquefied gas carriers, the Code for Existing Ships Carrying Liquefied Gases in Bulk, included expectations for loading, testing, and other procedures.

Liquefied gas carriers built today are subject to the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk; the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers; and other U.S. and international requirements that set the minimum safety culture requirements for specific liquefied gas operations. These, in combination with the ISM Code, create the robust safety management plan that incorporates all types of operations, yet even with all these regulations, it is only the start.

One of the reasons behind the industry's excellent safety record is the technical and operational guidance established by trade organization industry standards and company-specific policies. Organizations such as the Society of International Gas Tanker and Terminal Operators share experiences, address common problems, and derive agreed criteria for best practices that are used to set the "gold standard" safety culture.

whole length of the cargo spaces and inner hull warping, there was no loss of cargo or damage to the cargo containment system.⁴ These incidents validate the long-established safety culture and robustness in the design, equipment, procedures, and crew training associated with liquefied gas carriers.

So how has an industry that carries volatile cargo endured such an enviable safety record? Though the advent of the ISM Code did formalize the safety culture on liquefied gas carriers, it was the concepts put into place when the industry began and incremental improvements to those base concepts that really established the safety processes for communication, training, and actions aboard liquefied gas carriers. The industry leaders who developed and constructed the first liquefied gas carriers created the foundation, and subsequent generations built more and more robust standards onto these principals as the vessels became larger and more sophisticated.

The Liquefied Gas Carrier Safety Culture



Government regulations, industry standards, and company policies set the expectation for the safety culture.

Trained personnel are often the first line of defense, stringing together the remaining safety nets to address potential hazardous situations. Training requirements detail the courses, qualifications, and experience personnel must have to work aboard liquefied gas carriers. Personnel aboard are trained to understand the cargo, equipment, and operational and emergency procedures.

Operational and emergency procedures provide for practices to ensure a safe working environment. They are the time-tested, approved recipe for trained personnel to follow, incorporating processes for change to create continuous improvement. In addition to the process steps, the procedures detail roles, responsibilities, authority, communication, and reporting for those involved.

Various mechanical safeguards are installed to prevent, mitigate, and alert failures. These types of safeguards include gas detection; cargo pressure, temperature, and level detection; foam and other fire extinguishing systems; boil-off management equipment; pressure/vacuum reliefs; inert gas systems; intrinsically safe and flameproof electrical equipment; and water spray for cooling and wash-down.

The containment system is designed to protect the cargo in many ways. Cargo tanks are insulated to preserve the cargo's temperature (and therefore its pressure), contain multiple barriers and/or secondary containment systems in case of a breach, are made of materials that can withstand the cryogenic temperatures, and are constructed to support sloshing and other dynamic ship loads.

The liquefied gas itself is, in some respects, a safety net. Understanding the properties that make the cargo more safe vs. more risky is important. For instance, liquefied gas as a *liquid* is not flammable, but when vaporized, the gas produced is. There are many aspects of liquefied gases that make them safer than some cargoes, but there are also many that make them riskier.

Figure 2: The Liquefied Gas Carrier Safety Culture model depicts risk mitigation measures as five distinct safety nets, with governmental regulations, industry standards, and company policies as its backbone. U.S. Coast Guard graphic.

The Safety Nets

This industry-accepted safety culture that has evolved relies on more than just design and equipment; it relies upon five distinct safety nets (see Figure 2), with governmental regulations, industry standards, and company policies as its backbone. Trained personnel are the first line of defense to ensure safe liquefied gas operations. Designated personnel string together all the risks to avoid and address potential hazardous situations. Training requirements detail the courses, qualifications, and experience personnel must have to work aboard liquefied gas carriers. Personnel aboard are trained to understand the cargo, equipment, and operational and emergency procedures in order to take the needed precautions.

The next safety net is the safety management that ensures that the first line of defense—crewmembers—follow time-tested procedures. Safety management systems are the approved “recipe” for designated personnel, with details

on how the vessel should operate in normal as well as emergency situations; how drills and trainings are to be conducted; and the roles, responsibilities, authority, communication, and reporting expectations of the designated persons. In addition, these procedures include processes for change, which creates continuous improvement.

As a third safety net, various mechanical safeguards prevent, mitigate, and alert failures, including gas detection, cargo pressure, temperature, and level detection monitors; foam and other fire extinguishing systems; boil-off management equipment; pressure/vacuum reliefs; inert gas systems; intrinsically safe and flameproof electrical equipment; and water spray for cooling and wash-down.

The next safety net involves primary and secondary containment systems designed to protect the cargo in many ways. For example, refrigerated cargo tanks are insulated to preserve the cargo's temperature, and therefore its pressure.

Pressurized cargo systems are designed to withstand higher pressures. All of these systems are constructed to support sloshing and other dynamic ship loads, and contain some type of secondary containment system in case of a breach.

Finally, the most basic layer of safety involves recognizing the hazards associated with the cargo itself. Compared to other more commonly carried cargoes, there are many other characteristics of liquefied gases that make them more dangerous in some cases and safer in others. Differentiating what creates hazards from what doesn't drives the need for the remaining safety nets. For example, neither LNG nor its natural gas vapors are toxic, carcinogenic, corrosive, or even damaging to the water or ground if spilled. Additionally, liquefied gases aren't flammable when in a liquid state. However, when vaporized, the gas produced is. LNG vapor is also an asphyxiant, displacing the normal oxygen concentration to hazardous levels that could cause fatalities in certain concentrations. Understanding such risk and safety properties is important in developing other mitigation measures.

A Continuing Challenge

While the industry can be justifiably proud of the exemplary safety record it's built up over the first half of the century, current trends and changes to come within the industry give reason to remain vigilant. The number and types of liquefied gas carriers needed to support the nation's "Energy Renaissance" and increased use of liquefied gas throughout the maritime community are on the rise. Therefore, it's even more important that the long-running safety culture mentality be preserved and continually reviewed to address current trends and future operations.

While the Coast Guard has seen an increase in the number of liquefied gas carrier arrivals, we have also seen a disproportionate number of incidents (including near-misses) that have led to liquefied gas carrier detentions, due primarily to issues within vessel safety management systems. For example, a fire on a liquefied gas carrier in early 2015 was due in part to the crew not following its approved procedures, which led to a release in the pump room that came into contact with an ignition source and caught fire. Fortunately, the crew was able to extinguish the fire with minimal damage and injuries.

Additionally, several Coast Guard inspections have identified maintenance gaps with deluge systems on liquefied

The Numbers

We have reached a record: 1,751 liquefied gas carriers currently in the global fleet; that number is expected to rise to more than 2,000 in the next few years; and 358 ships are on the order books as of late 2015.¹ These vessels have increased in size from 600 cubic meters to upwards of 266,000 cubic meters. This growth in total volume is expected to be needed to meet energy analysts' prediction for future demand.

Experts forecast that global LNG trade will double within the next 20 years.² Additionally, a 25 percent increase in U.S. exports of liquefied petroleum gas (LPG) is expected in just the next three years. This includes the 13 new export facilities within the Gulf Coast alone that will triple the region's capacity by 2016.³

The U.S. is likely to top the LNG and LPG producers list by 2020. Additional growth in the U.S.-flagged fleet will come with LNG and other liquefied gases being used as fuel, including the 12 vessels under construction or already in service domestically and 144 internationally.

Endnotes:

1. Shipping Intelligence Network. Retrieved September 1, 2015, from Clarksons Research Services: <https://sin.clarksons.net/Register#/Fleet/Fleet/Vessel-Type>.
2. J-Y Robin, 2014, "An Achievement," LNG Shipping at 50, page 9, found at www.sigtto.org/media/7087/lng-shipping-at-50compressed.pdf.
3. J. O'Connell, Nov. 25, 2014, "The Other Gas: While LNG gets all the headlines, it's LPG that's really making waves." Retrieved September 1, 2015, from The Maritime Executive, found at www.maritime-executive.com/magazine/The-Other-Gas-2014-11-25.

gas carriers. The deluge system utilizes high-velocity water suppression to mitigate the risks associated with liquefied gas releases. To cover the hazardous areas, water is simultaneously diffused through a specifically designed number of sprinkler heads. On more than one recent occasion, however, the Coast Guard identified multiple sprinkler heads clogged with rust, preventing coverage in many critical areas. They found these failures were caused by improper use of and updates to maintenance procedures.

In both of these cases, proper implementation of the safety management system could have prevented each incident.

LNG as Fuel

Due to the environmental and cost benefits of liquefied gases—primarily LNG—some vessel operators have decided to shift to liquefied gases as a fuel. This adds another aspect requiring safety management.

In early 2015, the Coast Guard certificated the first U.S.-flagged, LNG-fueled commercial vessel. At the time they were inspecting the construction and certification of 11 more, from container ships to offshore supply vessels. Additionally, there were 144 confirmed LNG-fueled vessels either on order or under construction globally—adding ferries, bulkers, tankships, and towing vessels to the mix. Even cruise ship operators were jumping in, with Carnival Corporation recently constructing four of the world's largest cruise ships, each LNG-powered, carrying 6,600 passengers.⁵ In another example, a recreational boat builder began advertising a series of 12 LNG-fueled outboard yachts in 2014.⁶

As these new vessels come online, dependence on LNG fueling operations will follow right behind. Indeed, LNG bunkering services are already beginning to appear in ports around the world. While these vessels and fueling operations currently seem to be mirroring the safety culture found throughout the liquefied gas carrier industry, some wonder if the fueling operations will keep the same approach in the long run. As fueling operations become more abundant, competition will ensue, which may put financial pressure on operators—some relatively small-scale, with less backing than the liquefied gas carrier industry. As more and more operators enter the market and the pool becomes more diverse, some may no longer value or even recognize the unique hazards these new fuels present until it's too late.

Finally, what was once an industry of purpose-built liquefied gas carriers designed for specific facilities will soon welcome multipurpose vessels that need to go wherever and whenever. Each of the concerns mentioned increases the risk of incident for the industry as a whole. To help ensure there's guidance out there for vessel and fueling operators, organizations such as the Society For Gas as a Marine Fuel have recently been established to promote safety and industry best practices in the use of gas as a marine fuel.

Additionally, the Coast Guard has released four policy letters⁷ associated with LNG-fueled vessels and associated bunkering operations, and the IMO recently adopted the first-ever International Code of Safety for Ships using Gases or other Low-flashpoint Fuels to minimize risk to a ship, its crew, and the environment.⁸

As stricter emissions regulations and cost benefits make LNG an obvious choice, the U.S. will see more and more use of these types of maritime fuels, and the associated bunkering services to support this new domestic and foreign

need will create new operations in almost every port. As these predictions unfold, new challenges will surface that the industry, trade organizations, and regulators will need to consider. If this aspect of the industry expects to emulate the excellent safety record of liquefied gas carriers, it must hold itself to the same safety culture standards.

It will be paramount that the industry as a whole—from large-scale liquefied gas carriers to small LNG-fueled harbor tugs—ensures its focus on all aspects of safety, an adequate supply of properly trained and competent personnel, and the process of continuously assessing safety procedures. Maintaining this “gold standard” safety culture across the industry will be similarly paramount to consistently ensure the safe maritime transportation and use of liquefied gas.

About the author:

CDR Jason Smith is the detachment chief for the U.S. Coast Guard's Liquefied Gas Carrier National Center of Expertise located in Port Arthur, Texas, where he supervises a team of liquefied gas subject matter experts who provide technical advice to both the industry and the Coast Guard, increasing and maintaining the Coast Guard's collective competency and capacity to professionally engage with the liquefied gas industry.

Endnotes:

1. International Code for the Construction of Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code), 1993 Edition.
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6. “Intrepid to Debut Natural Gas Hybrid Boat In Fort Lauderdale,” October 21, 2014. Retrieved September 1, 2015, from Boating Magazine, found at www.boatingmag.com/boats/intrepid-to-debut-natural-gas-hybrid-boat-fort-lauderdale.
7. The four policy letters are as follows:
 CG-521 Policy Letter No 01-12 - Equivalency Determination - Design Criteria for Natural Gas Fuel Systems, US incorporation of Interim IGF Code plus additional design criteria for US vessels, found at <https://www.uscg.mil/hq/cg5/cg521/docs/CG-521.PolicyLetter.01-12.pdf>.
 CG-OES Policy Letter No 01-15 - Guidelines for Liquefied Natural Gas Fuel Transfer Operations and Training of Personnel on Vessels Using Natural Gas as Fuel, Operational criteria for LNG fueled vessels plus training expectations, found at www.uscg.mil/hq/cg5/lgcncoe/docs/LNGF%20Policy%20LTR.pdf.
 CG-OES Policy Letter No. 02-15 - Guidance Related to Vessels and Waterfront Facilities Conducting Liquefied Natural Gas (LNG) Marine Fuel Transfer (Bunkering) Operations, Operational criteria for LNG bunkering facilities (127 regs tailored for bunkering only facilities), found at www.uscg.mil/hq/cg5/lgcncoe/docs/Bunking%20Policy%20LTR.pdf.
 CG-ENG Policy Letter No 02-15 - Design Standards for US Barges Intending to Carry Liquefied Natural Gas in Bulk, US criteria for LNG barges (154 regs tailored for barges), found at <https://www.uscg.mil/hq/cg5/cg521/docs/CG-ENG.PolicyLetter.02-15.pdf>.
8. International Maritime Organization, June 26, 2015. Retrieved September 1, 2015, from Maritime Safety Committee (MSC), 95th session, 3–12 June 2015, found at www.imo.org/en/MediaCentre/PressBriefings/Pages/26-MSC-95-ENDS.aspx.

Making the Safe, Safer

Implementing safety management systems on domestic passenger vessels.

by MR. ERIC P. CHRISTENSEN
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Today's U.S.-flagged domestic passenger vessel industry is one of the safest modes of transportation in the United States. This is a testament to the professionalism of vessel operators as well as their commitment to maintaining a consistently high standard of safety for passengers and crew.

Though no injury or fatality is acceptable, this industry record is particularly significant, especially when you consider that according to the Passenger Vessel Association (PVA), the U.S. passenger vessel industry safely carries more than 200 million passengers each year. How did the passenger vessel industry develop such a record? The answer is simple—through broad recognition across all U.S. passenger vessel industry segments regarding the importance of safety, developing safety and training programs that work, and creating an atmosphere where all employees work toward a common safety goal.

In the world of safety management, one must never become complacent or satisfied with the status quo. Accidents will happen, so it's imperative to keep moving forward with safety-related activities and programs that will deliver ever-improving results. Along these lines, and in an effort to go beyond regulatory compliance, reduce risk, and seek continuous improvement, the PVA has worked to develop a voluntary safety management system (SMS) program called "Flagship," which is tailored especially to passenger vessel operators and scalable to operations of all sizes. The goal is to achieve an enhanced level of safety and environmental compliance through a proactive culture of continuous process improvement.

Why Look at Safety Management Systems?

There's no denying that any incident garnering media attention on a vessel shakes up public opinion of the passenger

What is a Safety Management System?

A safety management system is a structured and documented system enabling shoreside and vessel personnel to effectively implement company safety and environmental protection policies. It is a coordinated, comprehensive set of processes that help a company to most efficiently and effectively manage safety and environmental operations.

A safety management system combines management processes into one cohesive structure to achieve an enhanced level of safety and environmental compliance through a proactive culture of continual process improvement. A safety management system must contain the following functional standards and performance elements:

- ✓ a safety and environmental protection policy;
- ✓ instruction and procedures to ensure safe operation of the vessels and protection of the environment, in compliance with relevant rules and regulations;
- ✓ defined levels of authority and defined lines of communication between and among shore and vessel personnel;
- ✓ procedures for reporting accidents and nonconformities;
- ✓ procedures to prepare for and respond to emergencies; and
- ✓ procedures for internal audits and management reviews.



High-speed tour boat

Photo courtesy of Entertainment Cruises.



Passenger ferry

Photo courtesy of Fire Island Ferries.



Riverboat

Photo courtesy of Gateway Clipper Fleet.



Passenger/vehicle ferry

Photo courtesy of the Washington State Department of Transportation.

The unique, diverse nature of the domestic passenger vessel industry requires safety management systems that are equally unique, scalable, and appropriate to diverse types of operations.

vessel industry. The incident need not even be domestic, as was evidenced following the sinking of the Korean ferry M/V *Sewol* in April 2014 with the loss of more than 300 passengers, mostly children.¹ The PVA staff received numerous requests for comment regarding the incident, including the question “Can it happen here?”

Casualty statistics analyses conclude that more than 80 percent of all high-consequence marine casualties are directly or indirectly attributable to “the human element.”² These types of errors play a part in virtually every casualty—including those where structural or equipment failure may be deemed the apparent cause.

The National Transportation Safety Board has endorsed adopting safety management systems as a means to enhance transportation safety in the nation’s domestic ferry systems. Several ferry systems are currently operating with a safety

management system in place, and have already experienced direct and indirect benefits as a result.

For example, a safety management system prompts vessel operators to go beyond looking at accidents and incidents, analyzing more broadly to also address nonconformities found during routine maintenance and inspection. By identifying issues and potential problems impacting vessel operations, the vessel operator can make repairs or put procedures in place to mitigate identified risks.

The Regulatory Seascape

Currently, U.S. vessels engaged on foreign voyages and subject to the International Convention for the Safety of Life at Sea (SOLAS) must comply with the International Safety Management (ISM) Code. For passenger vessels, the ISM Code is currently only mandatory for those carrying more than 12 passengers on an international route. In 1997, the Coast Guard established an equivalent to ISM

Code compliance for small passenger vessels certificated under 46 Code of Federal Regulations, Subchapter T.

There are, of course, an entire group of U.S. passenger vessels that are not subject to SOLAS; therefore, they are not required to comply with the ISM Code. The Coast Guard has long sought to encourage voluntary compliance with the safety management system requirements of the ISM Code to the maximum extent possible on these domestic vessels.

Most recently, Section 610 of the Coast Guard Authorization Act of 2010 amended Section 3202 of Title 46 U.S. Code to include passenger and small passenger vessels with other vessels requiring a safety management system. However, there were no thresholds (passenger capacity, inspection subchapter, etc.) specified in the amended law. That's where the PVA Flagship initiative comes into play.

Flagship

Flagship is a safety management system appropriate and scalable for the domestic passenger vessel industry. While it does provide structure, it's also designed to be flexible enough to readily capture typical passenger vessel procedures and processes, document compliance with all applicable laws and regulations, identify nonconformities for corrective action and continuous improvement, and establish a program of audits.

In the name of enhancing regulatory compliance and safety on domestic passenger vessels, Flagship's goals are to provide PVA members with a program template, providing guidance to implement programs in a way that the Coast Guard will recognize and accept.

To develop Flagship, a chartered working group of PVA members and Coast Guard participants harvested best practices by reviewing existing public and private sector practices and processes for maintenance, management, and internal reporting systems. The working group also took the existing ISM Code template that the Coast Guard developed for small passenger vessels on international voyages and modified it to meet domestic requirements.

Observations So Far

Ten Passenger Vessel Association member companies are currently beta testing the draft Flagship code and guidelines the PVA/Coast Guard working group developed. A safety management system is iterative by design, and the more the

Who is This Elephant, and Why is He in the Room?

While voluntary compliance is a goal — and we should strive for it and show the public that Passenger Vessel Association (PVA) members take safety and environmental stewardship seriously — there's no denying that federal requirements are looming on the horizon.

The 2010 Coast Guard Authorization Act called for the Coast Guard to develop regulations requiring safety management systems on passenger vessels. That process is underway, but regulations take time.

While the Coast Guard doesn't need to reinvent the wheel regarding the elements of a safety management system, what it *will* need is the industry's input. Through the notice and comment process of rulemaking, the industry can suggest how best to implement safety management systems in an industry with an enviable safety record. If the PVA can show a model path to compliance through our voluntary safety management system, "Flagship," without overburdening our members, then we stand a good chance of influencing the regulatory outcome for the benefit of all.

beta test companies work with the code and guidelines, the more refined the system will become.

Further, while accident reporting is (arguably) clear in regulations, tracking and acting upon incidents that aren't defined as casualties but could still impact personnel and property is a work in progress. Another area not yet fully developed is the role of internal and external audits of company operations.

There are a number of members within the association that have already implemented a safety management system. Some have done so due to regulatory mandates associated with international operations, while others have found that a proactive system of continuous improvement leads to reduced accidents, greater vessel availability, and more widespread crew commitment to operate in a safe and environmentally sound manner. The level of interest in Flagship within PVA has dramatically increased as a result of having these experienced members share their safety management system experience with other members.

Moving Forward

As more PVA members embrace Flagship and safety management systems in general, Coast Guard engagement, commitment, and approval will be key to our success. We have already experienced their engagement through the quality

partnership and Flagship working group. Coast Guard commitment and approval will come as leadership establishes policies and procedures to recognize voluntary compliance, then train marine inspection personnel in the practice of auditing. Passenger Vessel Association members welcome Coast Guard involvement in conducting external audits on Flagship vessels and companies, as without the involvement and buy-in from local sector personnel, company commitment could wane under a cloud of indifference.

We understand that safety management systems are not a replacement for inspection; however, effective implementation should allow for increased intervals between inspections and a reduced scope of inspection during the validity of a certificate of inspection. Such incentives should be part of any future rulemaking to add benefit to the regulatory

cost/benefit analysis and to recognize the trust the Coast Guard is willing to put into vessel operators who demonstrate a higher commitment to safety.

About the author:

Mr. Eric Christensen is the director of regulatory affairs and risk management for the Passenger Vessel Association. He is a 1987 graduate of the California Maritime Academy and spent more than 26 years in the Coast Guard executing the marine safety mission as a marine inspector, policy maker, and program manager.

Endnotes:

- ¹ M. Park, "What went wrong on Sewol?" CNN.com, May 15, 2014, found at www.cnn.com/2014/05/15/world/asia/sewol-problems/.
- ² C.C. Baker and A.K. Seah, "Maritime Accidents and Human Performance: the Statistical Trail." Paper presented at MARTECH 2004, Singapore, September 22–24, 2004.

For more information:

The Passenger Vessel Association (PVA) is the national trade association for U.S.-flagged passenger vessels of all types. The PVA has more than 500 vessel and associate members who own and operate passenger and vehicular ferries, dinner cruise vessels, sightseeing and excursion vessels, private charter vessels, whale-watching and eco-tour operators, windjammers, gaming vessels, amphibious vessels, water taxis, and domestic overnight cruise ships.

For more information, go to: www.passengervessel.com.

One System

Connecting SMS requirements to vessel operations.

by LT JOSH BUCK
Investigating Officer
U.S. Coast Guard Sector New York

The International Maritime Organization (IMO) developed the International Safety Management (ISM) Code, which requires all ships to maintain a safety management system (SMS). However, in my experience as a U.S. Coast Guard marine inspector, quality management auditor, and investigating officer, I have noticed some detachment between documented management systems and actual operations.

In fact, the IMO found that the administrative burden for safety management systems was an issue regarding SMS use and implementation, according to a 2005 study,¹ and a 2013 vessel collision study found that SMS-related non-compliance and human error were the two main causal factors for the collisions.² Thus, when safety management systems aren't connected well to actual operations on a vessel, human error may be more likely to occur.

While the ISM Code is still a critical component of supporting safe vessel operations, it's clear that safety management systems may not connect to vessel operations as well as they should. While it's important for a vessel's operations to conform to the ISM Code and have an inherent SMS, in my opinion, the safety management system need not be a separate system.

Conforming to the ISM Code

In 2002, it became mandatory for each company operating ships applicable to the ISM Code to develop and maintain safety management systems for its vessels. The objectives of the ISM Code, particularly within the marine environment, are to:

- ensure safety at sea,
- prevent human injury or loss of life, and
- avoid damage to the environment.³

In essence, the ISM Code seeks to protect all stakeholders within the world's maritime transportation system. Its objectives align directly with a vessel's adherence to existing IMO requirements.

However, it creates some confusion when the ISM Code appears to mandate creating a separate safety system within a company, and, consequently, aboard a vessel. For example, why does a vessel need to maintain a safety management system when the functional requirements of ISM Code clause 1.4 (such as overarching safety, environmental, emergency, communication, and management policies) should already be a part of the vessel's operational system as a result of other requirements? A company SMS should already be built into a vessel's existing procedures, process, and operations.

This is similar to the process in which manufacturing companies become ISO 9001 certified through implementing a separate quality management system (QMS). Manufacturing companies don't need to implement a QMS, but rather ensure their system conforms to the QMS standard. Vessels and their parent companies don't need to maintain a separate system for safety management when that safety management should already be a part of a company's and vessel's operational system.

I relate it to asking a vessel master, "May I see your regulatory compliance system manual?" Why would a separate regulatory compliance system need to exist? The bottom line is that vessels and companies do not need to create a new and separate safety management system when they can incorporate their existing systems, procedures, and manuals into a safety management system to comply with the required standard.

A System-Based Perspective

A commercial vessel's main objective is to transport cargo or passengers from point A to point B safely, in a timely manner, and with minimal impact to the marine environment. To facilitate this, commercial vessel crews have regulations, company policies, drills, safety management systems, bridge resource management systems, plans, procedures, and a plethora of other safeguards to follow, meet, or implement.

Similar Requirements	
International Safety Management (ISM) Code Requirement	International Ship and Port Security (ISPS) Code Requirement
Clause 9 — Reports and analysis of nonconformities, accidents, and hazardous occurrences	Clauses 11.2.7 and 12.2.5 — Company and ship security officer reporting requirements
Clause 10 — Maintenance of the ship and equipment	Clauses 9.4.15 and 9.4.16 — Ship security plan
Clause 11 — Documentation	Clause 10 — Records
Clause 12 — Company verification, review, and evaluation	Clause 9 (numerous cites) — Ship security plan

While meeting this overall objective, a vessel's operational system should:

- conform to ISM Code requirements, thus becoming a safety management system;
- connect all vital vessel systems, from the keel to the master captaining the ship;
- include all the aforementioned safeguards.

The addition of a separate SMS documentation system seems burdensome—disconnected from the crew, port engineers, and other stakeholders.

A separate documentation system is beneficial for auditors and inspectors, but how beneficial is a safety management system for the actual vessel operators? I relate this closely to my quality management system research and experience, where an organization may have an actual production system but also maintains a QMS with its own documentation control, procedures, and processes distinct from the actual operations of the organization. Often a QMS or SMS is implemented just so a company can market that they have one.

The key is the overall objective and performance expectation clarity—not necessarily whether enough documentation exists to support a safety management system. Expectation and mission clarity is essential for any system to operate effectively. This is no different for vessel operations, where operational systems should connect to and be a subsystem of an overarching company system.

The ISM Code appears to imply a need for additional processes or procedures. For example, clause 5 of the ISM Code requires vessel masters to review their company's safety management system and report any deficiencies back to the vessel's company management,⁴ implying that the SMS is distinct and separate from vessel operations. This can be confusing, considering that all the vessel master really needs to do is report any deficiencies regarding a vessel's operational system, not vessel-related deficiencies and specific

SMS-related deficiencies—they should be one and the same.

Does a master need to report an engine deficiency and also document a safety management system deficiency for the same issue separately? Isn't clause 5 met any time a vessel master reports to shoreside management regarding any deficiency occurring in a vessel's operation system? Do safety management system manuals, procedures, checklists, and other documentation need to exist for companies and vessels to meet the ISM Code?

One System

I understand requiring that a safety management system exist, in part, for a company's external stakeholders to connect vessel operational systems to company processes. However, consensus standards like the ISM Code are much more manager- and process-focused than employee-centric. A company's SMS needs to be less emblematic, and more focused on employees—in this context, the mariners—who can make vessel operations safer.⁵ *Mariners* and *vessels* are the safety management system.

In a real-life example, I investigated one incident where a vessel captain hadn't followed company policy regarding emergency notifications. However, the company admittedly never provided the emergency notification information to the masters; the procedure was in a lengthy company document not readily available. To make it "one system," the company could have provided the master a checklist to follow when an emergency occurred. Then the master wouldn't necessarily need to know the policy, but still could have followed it because the system connected the shoreside office to vessel operations.

In summary, what good is a safety management system if mariners are not really engaged with it? When SMS non-compliance is noted after a casualty, it may behoove an investigator to assess whether the given safety management system was embedded into the actual vessel operations—and ultimately, into the practices of the mariners doing the work.

The IMO study regarding ISM Code implementation⁶ recommended:

- involving seafarers in developing and continuously improving ISM manuals;
- streamlining and reducing the paperwork supporting ISM compliance, particularly the SMS;

- identifying common areas of the ISM Code and the International Ship and Port Security (ISPS) Code and integrating documentary requirements.

I think these recommendations are still appropriate today. For example, the ISM and International Ship and Port Security (ISPS) Code both appear to require separate systems, plans, and procedures, as the ISPS Code requires a ship security plan,⁷ while the ISM Code requires a safety management system. These requirements could be met through a holistic company and vessel operations manual. Even further, the ISPS Code and ISM Code require procedures for reporting and recommending improvements, which could be combined within one company system.

Duplication of effort in any system leads to waste. A company could maintain one standard operations manual that addresses appropriate requirements from both the ISM and ISPS Codes, which would serve as a safety management system. When all components of a system are running smoothly and efficiently, there's no need for "separate" systems. Could you imagine a company trying to implement a quality management system, safety management system, and security system? That doesn't seem beneficial to me. Companies operating vessels need to have one system that conforms to applicable codes and standards—one system to rule them all and serve as the SMS.

Auditing One System

The next question is how to monitor and improve a system. In my experience, auditors typically verify how well a system conforms to the ISM Code (in addition to many other standards) by spending the majority of their time reviewing documentation, processes, and procedures. I've found that minimal time is spent observing actual operations.

What may be more beneficial are observatory audits, where auditors observe actual operations to ascertain why employees do certain things, then work to discover ways to improve

operations. The commercial airline industry already uses this process. These observatory audits produce a valid picture of operations, and in vessel operations the audits could identify gaps between ambitious company safety management system requirements and real-life vessel operations.⁸

The observatory audits may allow mariners to provide better feedback to company personnel managing vessel operations. For example, rather than review documentation that proves employees submitted corrective actions, an auditor would experience the mariner submitting a corrective action report, noting any impedance in the process. Observatory audits could pave a way for many companies to shed unwanted documentation and connect the dots—all in one system.

About the author:

LT Josh Buck has served in the U.S. Coast Guard for 10 years in multiple capacities, most notably as a marine inspector, quality management auditor, and marine casualty investigator. He holds an M.S. in IT management and a B.S. in logistics.

Endnotes:

- ¹ International Maritime Organization, "Role of the Human Element: Assessment of the impact and effectiveness of the ISM Code," 2005.
- ² C. Chauvin, S. Lardjane, G. Morel, J. Clostermann, & B. Langard, "Human and organizational factors in maritime accidents: Analysis of collisions at sea using the HFACS," 2012. *Accident Analysis and Prevention*, 59, 26–37. doi:10.1016/j.aap.2013.05.006.
- ³ International Maritime Organization, "International Safety Management (ISM) Code," 2010.
- ⁴ Ibid.
- ⁵ J.K. Wachter and P.L. Yorio, "A system of safety management practices and worker engagement for reducing and preventing accidents: An empirical and theoretical investigation," 2014. *Accident Analysis and Prevention*, 68, pp 117–130. doi:10.1016/j.aap.2013.07.029.
- ⁶ International Maritime Organization, "Role of the Human Element: Assessment of the impact and effectiveness of the ISM Code," 2005.
- ⁷ International Maritime Organization, "International Ship and Port Security (ISPS) Code," 2003.
- ⁸ C. Chauvin, S. Lardjane, G. Morel, J. Clostermann, & B. Langard, "Human and organizational factors in maritime accidents: Analysis of collisions at sea using the HFACS," 2012. *Accident Analysis and Prevention*, 59, 26–37. doi:10.1016/j.aap.2013.05.006.



The IMO Mandatory Member State Audit Program

Appraising the flag.

by MR. JOHN J. HANNON
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 Domestic Vessel Compliance Division
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On January 1, 2016, the International Maritime Organization (IMO) implemented a mandatory system of audits for its 170 member states to verify the degree to which each member state effectively implements the mandatory IMO instruments to which it is signatory.¹ This mandatory program follows a successful voluntary program that ran from 2006 to 2015, in which the United States and approximately 70 other member states participated. Going forward with the mandatory system, experienced government maritime authority personnel from the IMO member states will conduct these mandatory audits, and the London, U.K., International Maritime Organization staff will support these volunteer auditors to ensure audit program continuity and consistency.

The audits will highlight areas where IMO member states demonstrate exceptional competence in implementing the IMO instruments and note areas where further development is needed to achieve full, effective implementation. The member states that did not participate in the voluntary program are first in line to be audited, followed by those that participated in the voluntary audits.²

Triple I

The audit standard comes from the International Maritime Organization Code for the Implementation of IMO Instruments (referred to as the “triple I” or “III” Code).³ As such, the audits focus on maritime safety and environmental protection programs; maritime security programs aren’t included in the audit scheme.

Each member state will have access to a summary of the audit findings, including any observations and nonconformances, but without attribution to the member states involved. The full audit report will only be available to the

auditors and the audited member state unless the member state voluntarily elects to make the report public. For example, the U.S., among many other nations, has chosen to make public the full IMO voluntary audit report.

The member state must submit a corrective action plan to the International Maritime Organization for all nonconformances in the audit report, but the IMO won’t make those corrective actions available to other member states.

The International Maritime Organization subcommittee for Implementation of Mandatory IMO Instruments (also known as the III subcommittee) has a standing work group that annually evaluates the findings to examine areas where the IMO could improve instrument implementation. The III subcommittee may make recommendations to the parent IMO committees for additions, deletions, or amendments to one or more of the IMO mandatory instruments if the audit findings reveal that some provision has proven problematic when it comes to effective implementation.

The main areas of the audit are:

- common areas,
- flag states,
- port states, and
- coastal states.

The applicability of these sections varies from country to country, depending on the geographical location of the member state and organization. For example, some IMO member states are landlocked, with no sea ports or coastline whatsoever. However, these member states register ships under their flag, and therefore, have responsibility to implement the IMO instruments that apply to those ships. So, in such an instance, the audit would omit the port state and

coastal state areas, focusing only on the common and flag state areas.

Common Areas

As the name implies, “common area” requirements apply to all member states, regardless of location and fleet composition. The focus is on organization, resources, and planning to ensure that international obligations and responsibilities as a flag, port, and coastal state are met. The III Code notes that each state should also monitor and assess effective implementation and enforcement for relevant international mandatory instruments, and should continuously review its strategy to maintain and improve overall organizational performance and capability as a flag, port, and coastal state.

An example of a common area for all member states is enacting national laws and regulations. Every IMO member state must give force to the mandatory IMO instruments to which it is signatory via its national laws, regulations, policy, and procedures. Depending on the legislative and administrative structure of each member state, this can be a protracted process. Maritime authorities within each nation must devote time and resources to accomplishing this task, and, in many instances, they may be in competition with other pressing issues before their national governments and legislative bodies.

Further, the volume of new International Maritime Organization regulations has, in some instances, outpaced the ability of some member states to enact national laws before the IMO mandatory instrument went into force. For example, the voluntary audits revealed numerous instances where member states implemented International Maritime Organization regulations via the rules of their recognized organizations (class societies, in most cases), but still lacked corresponding national laws.

This could put the recognized organizations in a difficult situation, inasmuch as they act as agents of national governments to grant or deny international certificates the International Maritime Organization regulations require. Additionally, even though maritime administrations can’t control the priorities of their national legislative bodies, the International Maritime Organization views implementing its instruments as a national responsibility—not just the function of an isolated entity within a government.



Captain Lonnie Harrison (6th from the left), USCG, and his team of IMO auditors (4th and 8th from the left) pause during a voluntary IMO member state audit of Ireland. U.S. Coast Guard photo courtesy of CAPT Lonnie Harrison.

Flag State

The very heart of the IMO audit is the member state’s responsibility to ensure that the ships that fly its flag are safe and environmentally compliant. All other International Maritime Organization regulations spring from this basic principle. So even when inspection functions are delegated to third-party organizations, the ultimate responsibility to verify compliance with the IMO instruments remains with the member state.

That said, the III Code allows delegating inspection and survey functions to recognized organizations, and most IMO member states do rely on recognized organizations to provide the global reach necessary to carry out all of the inspections and surveys IMO regulations require. To ensure that these third parties meet high standards, the International Maritime Organization recently created a code for recognized organizations, and each member state must verify their recognized organizations meet code requirements.⁴

The U.S. delegates various inspection activities to a variety of recognized organizations, primarily International Association of Classification Societies member classification societies. The Coast Guard is tasked with fulfilling its duties for oversight under the IMO instrument, and has fully adopted the IMO framework in the recognized organizations code as the model for its oversight program.

Port State

These are the activities related to control of vessels not flagged under the member state that are in the ports or waters of the member state. As noted in the flag state discussion, the primary responsibility to verify that a ship is in compliance with the IMO regulations lies with the flag state. However, port states are allowed to verify that ships arriving in their ports and waters are in compliance.

The International Maritime Organization has established guidelines for port state control; the IMO auditors will verify that member states are operating their port state control program in accordance with those guidelines. Also, this area of the audit includes the responsibility of the port state to prevent pollution by providing facilities for accepting and properly disposing of oil, sewage, garbage, and other waste from the ships that call in their ports.

The Coast Guard conducts port state control examinations for foreign vessels visiting the U.S. using a well-defined system that prioritizes examinations based on a variety of factors. The Coast Guard publishes an annual report that summarizes the results of these examinations, including by flag.⁵

Coastal State

These are the areas where member states provide for the safety of ships and persons on or adjacent to their coastline. This includes, among other things:

- search and rescue capability,
- aids to navigation,
- charting/hydrography for the coastal waters of the member state.

Depending on the geography of the member state, the need for capability in this area varies greatly. The U.S. has significant resources and capability in all these areas, due to its extensive coastline.

Looking Ahead

There can be an unfortunate negative connotation associated with any audit program, and some may perceive that the IMO member state audit program is simply intended to criticize member states that lack the resources to perform

at a level comparable to a developed nation such as the U.S. The proper view of the audit system is that the findings of the audit will assist the member state by identifying areas where improvement is needed. Conversely, for those member states the audit identifies as exceptional performers in certain areas, the audit system may provide a source for other member states to learn from best practices.

The International Maritime Organization audits are unique because they're carried out by member state government personnel who are themselves active with implementing the IMO instruments for their own member state. In this sense, the audit is a form of shared capacity among IMO member states and a peer review that can provide perspective immensely helpful to the member state being audited. When viewed from this perspective, it is a positive move toward more consistent and effective international implementation for the International Maritime Organization mandatory instruments, which benefits all.

About the author:

Mr. Hannon has served with the Coast Guard for 38 years. He was a marine inspector as a Coast Guard officer on active and reserve duty. As a civilian employee at Coast Guard headquarters, he develops regulations, policy, and procedures for inspection and certification of U.S.-flagged commercial and military sealift vessels. He is a U.S. delegate to the IMO III subcommittee, a member of the IMO audit scheme work group, and is an IMO lead auditor.

Endnotes:

- ¹ IMO Res. A.1067(28) on the Framework and Procedures for the IMO Member State Audit Scheme, December 13, 2013.
- ² IMO Res. A.1068(28) on the Transition from the Voluntary IMO Member State Audit Scheme to the IMO Member State Audit Scheme, December 13, 2013.
- ³ IMO Res. A.1070(28) on the IMO Instruments Implementation Code (III Code), December 13, 2013.
- ⁴ The III Code specifies "The flag state shall establish or participate in an oversight program with adequate resources for monitoring of, and communication with, its recognized organization(s) in order to ensure that its international obligations are fully met."
- ⁵ U.S. Coast Guard, Port State Control in the United States, 2014 Annual Report.

Nothing to Fear

Objective auditors drive quality throughout organizations.

by CAPTAIN INDERJIT ARORA
President and CEO
Quality Management International, Inc.

The International Safety Management Code, International Ship and Port Security Code, and other relevant standards (ISO 9001, 14001, and 28000) allow marine operators to remain viable and prevent losses.

How do we gauge the effectiveness of such systems? Audits—which most mariners aren't fond of, and are generally seen by those aboard as an unwanted intrusion into a vessel's working routine. This "interruption" can also make masters nervous that auditors will find nonconformities, especially given the nature of short-term contractual employment at sea.

Internal process monitoring should result in improvement, building a culture that helps employees to determine and meet the process requirements. Where organizations lack the culture of the system approach, individuals are typically blamed for any and all failures. Eventually, these individuals fall back and rely solely upon the occasional visit by their auditor. Is it any surprise, then, that this visit is feared?

Audits don't have to be so stressful, given a slight shift of perspective. Instead of asking "Who?" every time something goes wrong, asking "How?" and "Why?" would strengthen the system approach and remove the fear culture of being blamed.

Nonconformities

Instigating this fear culture is "The Scarlet N"—nonconformities. Some organizations don't want to know about their nonconformities, and that's a pity, because, in reality, the only "bad" nonconformity is the one an organization doesn't know about.

In my opinion, some audit processes fail, in part, because maritime audit experts have failed to teach others to appreciate how the bottom line is positively enhanced by

addressing and predicting nonconformities, recognizing risks, and changing/updating processes before subsequent nonconformities occur.

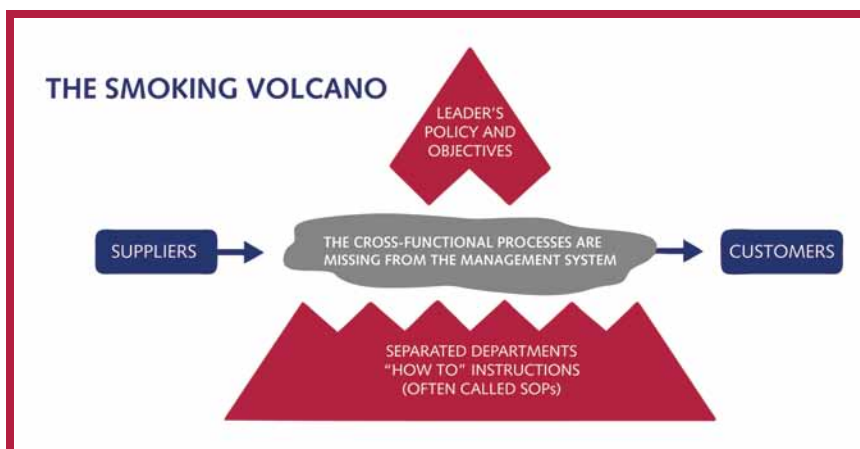
While nonconformities invariably stem from an audit, they should be raised by anyone who notices one, proactively driving corrective action. For example, some shipping companies have employed near-miss reporting/STOP card systems. The STOP (Safety Training Observation Program) program is a behavior-based safety program developed by E.I. DuPont de Nemours & Co. designed to prevent injuries and occupational illnesses in the workplace through training. For example, STOP® For Each Other is a member of the award-winning DuPont family of workplace safety training offerings.

Management Buy-In

Even if an organization embraces nonconformities as a call to improved action, the systems that result will be poorly implemented if leaders lack commitment to them. It has been shown, time and time again, that lack of buy-in by management is the number one variable responsible for establishing a fearful audit environment, ultimately leading to failure of a quality system, irrespective of well-trained auditors.

Each individual aboard a vessel as well as those involved in the vessel operations ashore are responsible for vessel quality, safety, and security. That said, ultimate responsibility can never be passed off down the chain to the vessels and crews who operate them. Top management must take responsibility for system performance, with continual improvement as the underlining goal. They can delegate their authority only if properly bundled with the right resources to get the job done.





A process-based system bridges the disconnect between the management creating procedures and processes and the crew carrying them out.

When top management commits itself, leading the various procedures and processes, much of the apprehension associated with audits eventually evaporates. Only then does the crew accept that an audit is a vital part of the success of their system.

Qualified Auditors

Once we envision an organization where nonconformities are helpful indicators and management provides the systems, resources, and consistency to fuel continued improvement, then we have a clean slate to show how auditors contribute to this culture of safety and success.

We begin with the concept of a well-trained, qualified auditor—anything less and management will likely lack the important buy-in just discussed. Today, a larger percentage of maritime auditors are mariners themselves, primarily because they know the environment so well. This can be a mixed blessing, especially since, like any profession, auditing has its own concepts and training requirements.

In general, auditing begins with ethics and performance-based objectives, not ulterior motives. Well-trained auditors don't seek out ways to penalize crews for nonconformities; rather, they see their role as looking for evidence of system conformity.

Auditors Adding Value: A Well-Defined Nonconformity

Where the system doesn't appear to meet requirements, the auditor must serve the audit client by providing detailed, objective evidence explaining the disconnect. Auditors add value not by giving advice, but by reporting nonconformities based on actual requirements and supported by the evidence observed. In the end, that should be the only expectation from a good auditor: a well-defined, objective nonconformity.

Maintaining this integrity in such a black-and-white fashion should save those under the microscope feelings of defensiveness—they either meet the requirement or they don't. Also, there should be no reason to fear this valuable interaction once we've added to that the previously discussed perspective of seeing nonconformities as helpful indicators.

Auditors add value by examining evidence of how well the system helps its users to recognize risks and predict potential nonconformities by analyzing data and getting useful information. This information should provide the trends and analyses to make decisions regarding resources and measures to improve efficiency, mitigate risks, and cut losses before they occur.

Conflicts of Interest

Flag state administrations, registered organizations, and registered security organizations should support the auditing system by avoiding conflicts of interest. For example, when a registered organization represents the flag state for certifications and then also chooses (or is nominated by principals) to be the consultant and trainer, the objectivity of the audit comes into question. Every stakeholder in the maritime industry must commit to maintaining the independence of the auditing institution—a premise not unique to maritime auditors alone, but one that stretches across the breadth of the supply chain.

Self-Audits: Empowering the Workforce

Auditing shouldn't take the place of self and supervisory monitoring. Such monitoring involves the personnel who perform and supervise the work—in particular, the designated person, company security officer, superintendent, and so forth—who provide the first layer of objectivity regarding how well their processes are fulfilling objectives. A system that uses only external audits as a single source of system conformity inputs is inefficient and indicative of system failure.

As stated earlier, internal process monitoring should result in rapid improvements, building a culture that helps employees to determine and meet the process requirements. Eventually, the first set of nonconformities coming from internal sources will remove the fear of audits; nonconformities will be found, reported, and dealt with ... and life will go on—hopefully, for the better.

Audits: Reasoned Processes to Improve Quality

While 5 to 10 percent of the success of a system can be attributed to the auditor/audit team, the other 90 to 95 percent of the solution resides with the leadership and their team.

An audit of any of the standards or codes should ideally be carried out by independent, mature auditors for the sole purpose of determining whether or not the system in place is working as desired. With top-to-bottom client buy-in, if nonconformities are discovered, the information should be welcomed and respected as a starting point to initiate the corrective action process. Any disconnect between leadership policy and the work-level manpower should be recognized as a weakness. A good system should bridge this gap, and if it is, indeed, a gap, an audit would make a finding to that effect.

The entire evolution, however, depends primarily on the total commitment of leadership to the process-based management approach to implementation of the ISM Code, the ISPS Codes, and other relevant standards. A viable, safe, and profitable merchant marine hangs in the balance.

About the author:

Captain Inderjit Arora is the president and CEO of Quality Management International, Inc. (QMII). He serves as a team leader for consulting, advising, auditing, and training clients in management systems, including many courses conducted for the USCG, and is a sought-after speaker at several universities and forums on the subject. He is a master mariner who holds a Ph.D., Master of Science, and MBA as well as a 32-year record of achievement in the military, mercantile marine, and civilian industry.

Checklist for Operators

1 Auditors don't improve a system.

- ✓ Auditors have never improved a system and never will; it's the top management/leadership who improve a system by their commitment.
- ✓ This article urges organizations to recognize that the best service their auditors can provide is to be objective and give an organization correctly written nonconformities (NCs) based on a requirement with clear, correct, and factual evidence, with the nature of the NC clearly stated.

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2 Nonconformities are integral to any system improvement. They should be welcome. The only "bad" NC is one not known by the organization.

- ✓ A nonconformity is the starting point for a correction and corrective action based on root cause analysis.
- ✓ A closed NC forms the data point leading to a database from which information can be drawn to analyze and predict potential NCs, appreciate risk, and appreciate trends.

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3 The maritime industry can meet the objectives and functional requirements of the International Safety Management Code by ensuring that:

- ✓ Auditing is objective.
- ✓ One must never consider the auditor a subject matter expert.
- ✓ Auditors do not compromise their independence as auditors by providing advice; doing so is counterproductive and kills an organization. Only the top management should be responsible for corrective action.
- ✓ An auditor performs yeoman service by giving a well-worded objective.
- ✓ NCs encompass the requirement, evidence, and nature of the NC.

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4 Auditors must be qualified.

- ✓ Being a mariner is not sufficient.
- ✓ Like other disciplines, auditing is a profession, which requires training leading to competence. Competency based on exposure must be strengthened by training and certification as an auditor.

Audits vs. Inspections

What's the difference?

by MR. ANTHONY D. MORRIS
Mission Management System Administrator
Force Readiness Command
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With America's port activities constantly changing and growing, the Coast Guard has been forced to rapidly ascertain the impact to our workforce demands to effectively meet our maritime customers' and partners' needs.

For example, it's imperative that the Coast Guard continues to facilitate commerce in a secure and safe environment. To help meet this demand within the scope of our stated mission requirements, Coast Guard leadership must innovate and adapt different methods to carry out mission requirements. One such area of focus involves reviewing our overall maritime compliance regimen to look for opportunities to audit overall systems as a means to achieve and maintain compliance from our maritime customers and partners.

So what is the difference between auditing and inspecting? Can auditing be used as our primary source to determine compliance? Are inspections still a useful tool as part of our overall security and safety compliance strategy?

Audits Versus Inspections

Auditing is a process that independently evaluates and measures procedures, processes, and standards. The process may include reviewing work instructions, guidelines, laws,

regulations, or other government or commercial requirements, including contracts.

The audit determines conformity, shows if procedures were performed as intended, and determines whether each requirement was followed or executed as planned. In short, audits are generally designed to verify conformity to stated requirements.

Unlike audits, inspection activities and processes tend to be more specific. For example, an inspector might do an in-depth examination of an action or piece of equipment to make sure it's doing the exact thing it's supposed to do as it relates to the function of the overall system. In most inspections, there is usually a dedicated checklist with specific items that need to be visually checked or seen operating to ensure they exist or properly function.

Inspections determine compliance with a specific regulation or standard, are generally designed to find deficiencies or nonconformities, and are conducted with much greater frequency than audits. In sum, the result of an inspection might be that a specific piece of equipment is found to be not functional, whereas the findings of an audit might



Inspections, such as this one of an engine control room, are imperative to discovering deficiencies. U.S. Coast Guard photo by ENS Jordan Ortiz.

be that the system designed to maintain the equipment is not functional.

More on Audits

Audits are not “pass/fail.” They help to identify nonconformities (weaknesses or areas of concern within a working system) so that workers know to take some sort of corrective action. Audits are designed to be nonpunitive, identify where improvement is necessary, and employ a predetermined process to execute appropriate corrective action. In addition, once the corrective action is taken, further steps are noted to prevent nonconformities from recurring.

Audits should not be feared—by design, auditors use an agreed-upon standard to measure effectiveness and overall system compliance. While audits are conducted on a periodic basis and are usually less frequent than inspections, they are generally better at identifying



Subject matter experts review documents associated with Standards of Training, Certification, and Watchkeeping requirements taught at a maritime academy. U.S. Coast Guard photo by Anthony Morris.

Audits identify systemic issues; inspections determine if system parts function as intended.

Audit result: The system designed to maintain the equipment is functional/not functional.

Inspection result: Equipment is functional/not functional.

systematic conformance and nonconformance that can be traced back to an overarching requirement.

This is important for audits and auditors, because it clearly shows the requirement for a process to function as designed. Audits don't rely on guesswork or possibilities; audits use existing requirements to determine conformity.

More on Inspections

Inspections have been a longstanding tool within the Coast Guard, handed down through generations of personnel within prevention and other program elements. Inspections ensure that deficiencies are discovered and proper



Ekaterina Minaeva/iStock/Thinkstock

What This Means for the Coast Guard

Both audits and inspections are important Coast Guard tools, and continued growth in America's port activities, changes in commerce and the maritime industry, and response to disasters means that the Coast Guard must use every tool possible to keep pace and effectively facilitate commerce.

As new legislation is promulgated, Coast Guard leaders often issue new or modified regulations and policies, which field personnel must implement and enforce. It is therefore critical to understand systems and processes to ensure regulation and policy effectiveness.

The Mission Management System

Since adopting the mission management system (MMS)—a set of policies, processes, and procedures to plan and execute established requirements—to support this effort, auditing has become a valuable tool to provide managers with the feedback necessary to make more informed decisions and achieve greater conformity to system requirements.

The MMS and auditing performance results provide Coast Guard leaders with a better idea of the effectiveness of their efforts to execute our mission and keep pace with a growing maritime industry.

IMO Audits

As a member of the International Maritime Organization (IMO) and a volunteer for the now-mandatory IMO member state audit scheme, the Coast Guard is required to audit its port state, flag state, and coastal state instruments to analyze how to implement, enforce, and harmonize international and domestic requirements.

By using audits to periodically check on the progress of efforts to conform to these system requirements, and by using inspections as a tool to frequently verify and correct the details within the system, the Coast Guard will be able to demonstrate overall conformity to the audit scheme's requirements.

fixes implemented, which can save lives, save property, and reduce costs.

Inspections may also generate results that can be analyzed as lagging trend indicators. By reviewing historical inspection records, inspectors can identify certain problem areas, which can help them to develop regulations or policy to enhance safety or security. This data can also help leaders determine how resources should be used to maximize compliance with regulations or policies.

Audit and Inspection Synergy Benefits

Audits identify systemic issues that can reveal trends of conformity and nonconformity within the system, and inspections can ensure that the individual parts of the system are functioning as intended. Therefore, the synergy between audit and inspection can be used to more effectively employ our limited resources.

For example, audits can measure system performance to allow for better trend analysis, which can identify areas that need a more detailed review or functionality inspection to determine if preventive measures should be taken.

Audits are not pass/fail.

About the author:

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A Tale of Two Ships

Examining SMS similarities, strengths, and weaknesses.

by MR. KEITH FAWCETT
Investigations National Center of Expertise
U.S. Coast Guard

Each year, Coast Guard marine investigators conduct investigations into marine casualties. Part of that process involves examining the vessel's safety management system (SMS). Two unique incidents in 2012 and their follow-on investigations give us unique insight into this process.

The year started with an allision, as a motor vessel ran into a highway bridge on a lake in Kentucky, causing a 300-foot bridge span to drop onto the vessel and into the Tennessee River. As 2012 ended, another vessel in the Gulf of Alaska struggled to control a mobile offshore drilling unit (MODU), which eventually grounded. Both vessels were conducting unique operations in unique environments.

Delta Mariner—The Incident

In late January 2012, the motor vessel *Delta Mariner* was carrying rocket motors in her cargo bay as she transited the Tennessee River en route to Cape Canaveral, Florida.¹ As she neared the Eggnor's Ferry Bridge that spanned the Tennessee River in the vicinity of Aurora, Kentucky, it was raining, but the rain was easing up.

Up ahead loomed the highway bridge, where a buoyed channel and sailing line on the U.S. Army Corps of Engineers river chart indicated the main channel. The vessel crew included a team of capable merchant marine officers. In addition, the vessel operators put a marine contract pilot aboard to assist the ship's officers on this segment of the waterway.² This was not a regulatory requirement, but a proactive safety practice for the operating company. The ship also had a safety management system in place.

As the ship neared the highway bridge, personnel noted that the lighting on the bridge wasn't quite right; there were discrepancies in the correct lighting scheme for the bridge. Most importantly, the center of the main navigational span, where larger vessels travel, was supposed to have three powerful white vertical lights to distinguish that span and the centerline of the channel for vessels required to transit that section of the bridge.³

As the minutes ticked by, the pilot decided to alter the ship's course to steer for another span that was adjacent to the lighted recreational vessel span, closer to the right side of the shoreline. Time was short as the ship moved off the sailing line indicated on the electronic chart and headed for that opening. Moments later, the



The M/V *Delta Mariner* anchored to the river bottom in Kentucky Lake on the Tennessee River with the span of the Eggnor's Ferry Bridge draped across her bow. Photo courtesy of the National Transportation Safety Board.

Spreadsheet developed aboard the M/V *Delta Mariner* showing the bridges and overhead obstructions on the inland waterway where overhead restrictions would be a problem. The ship's officers used colors to highlight the potential for danger. U.S. Coast Guard photo.



This photo looking forward toward the after superstructure of the M/V *Aiviq* shows some of the complex systems aboard the vessel, such as towing, firefighting, and lifting equipment. U.S. Coast Guard photo.

vessel struck the low-hanging bridge span, and the bridge span fell onto the bow of the ship and into the waters of the Tennessee River.

MODU Kulluk — The Incident

In December 2012, the motor vessel *Aiviq* was towing the MODU *Kulluk* across the Gulf of Alaska. As the voyage progressed, the ship encountered a series of severe weather systems that tested her towing plans. On December 27, the towing gear failed, setting the MODU *Kulluk* adrift with her 18-man crew.⁴

The *Aiviq* ultimately lost all main propulsion engines that day. Luckily, the vessel had a series of electric thrusters, including one rotating thruster, which allowed her some limited maneuverability and towing power. Over the next four days, the *Aiviq* response vessel crews, helicopter crew, shoreside support personnel, and unified command members mitigated the worst of the effects of the incident, but on December 31, the *Kulluk* grounded on the shore of Alaska.

Searching for Links

Here we have two unique, purpose-built ships; two different accidents; and great peril for the people, environment, and property involved. Where are the safety management system links?

In both cases, the ships were carefully and thoughtfully designed for their unique missions. The *Delta Mariner* had masts that could be lowered, and featured a low-profile

vessel design for transiting bridges and other overhead obstructions on her transit segments through America's inland waterways. Her propulsion system incorporated a rotating twin screw propulsion system, with additional thrusters and controllable-pitch propellers. The *Aiviq* featured an icebreaking hull along with multiple thrusters, controllable-pitch propellers, and a state-of-the-art towing winch with a tension monitoring system to check the strain on towing equipment.

As the investigations unfolded, the investigators looked at the accident scenes, vessels, shoreside management personnel, and all the related facets. Then, as a matter of routine, the investigators reviewed the procedures, policies, job aids, plans, checklists, and vessel safety management systems. Investigators went on to look at each vessel's specific operational history to

determine if vessel operators had identified lessons learned from past operations as well as the specific risks the vessels could have encountered over a significant operating period.

In the case of the bridge allision, the vessel involved had transited that particular bridge on numerous occasions, while in the case of the towing operation, this was the vessel's first winter transit through the Gulf of Alaska—a voyage of more than 1,700 nautical miles.

Delta Mariner — The Investigation

In the case of the *Delta Mariner*, the ship had a safety management system in place to address the challenges it was expected to encounter along the route, including the numerous bridges and high-tension power lines the ship would transit beneath.

The ship also employed a marine contract pilot to provide the ship's officers with advice along the route. In the case of the marine contract pilot, the SMS needed to address the role of the pilot as well as the master/pilot information exchange, so that prior to handling the vessel, the pilot would understand the unique characteristics of the vessel as well as any problems they might have to deal with using critical ship equipment.

The vessel's SMS did discuss the pilot/master exchange and the pilot's role and duties, but investigators had to determine if that SMS procedure was followed as specified.

According to the National Transportation Safety Board (NTSB) report:

The investigation revealed that the Delta Mariner's safety management system, developed by the company more than 10 years earlier and in place at the time of the accident, was not effectively implemented. Overall, [the company] provided ineffective oversight of the Delta Mariner's operations.

Due to the vessel's good safety record and the company's reliance on proactive safety measures and a crew of well-trained, experienced deep-sea mariners to provide a high level of safety, the company became complacent regarding the safety of the vessel's operations.

The investigation also found the expertise required of contract pilots was not clearly defined, and contract pilots and the Delta Mariner's deck officers lacked clear understanding of the guidance expected from contract pilots while serving on the bridge of a vessel.

In addition, the safety management system discussed a passage plan, which is used to plan a voyage and take into account all difficulties the vessel expects to face along the transit. The passage plan was also supposed to detail the strategies proposed to mitigate any risks encountered.

The NTSB report noted:

[The company's] safety management system documents stated, 'A passage plan is of no value unless it is utilized by all team members — including the pilot.' Investigators found no evidence, however, that the passage plan was reviewed by deck watch officers during the voyage.

The National Transportation Safety Board report also noted:

As the vessel approached Eggner's Ferry Bridge, the bridge team and contract pilot of the Delta Mariner were largely unaware of what lighting should have been visible on the bridge and which span allowed sufficient clearance for safe passage.

The contract pilot and bridge team focused exclusively on the few lights visible on the bridge while ignoring readily available electronic charting system displays, which could have provided critical information about the vessel's position in relation to the bridge and the bridge's correct lighting scheme. Despite this lack of information, the contract pilot continued to direct the vessel toward a span that was too low for the Delta Mariner. Further, despite the contract pilot's apparent uncertainty, none of the bridge team challenged his directions.

The SMS in place on board the Delta Mariner addressed the company's expectation for bridge team management, including maintaining a focused watch, the open exchange of information, the prevention of distraction, and the creation of a team environment. The practice of good seamanship was to be observed at all times on watch, and each individual on watch was required to be alert and attentive to their respective duties relevant to the safety of the vessel.

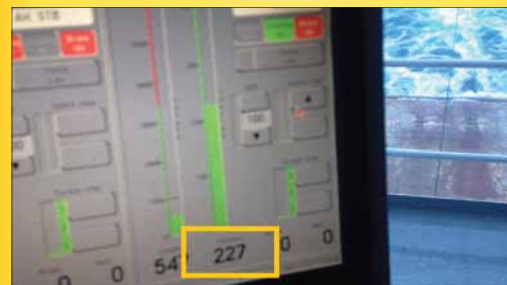
The master and DWOs⁵ were instructed to always 'remain alert to the pilot's or mooring master's handling of the vessel and be prepared to intervene when necessary to safeguard personnel, environment, vessel, or cargo.'

The NTSB report further refers to a sequence of events that began as the ship approached the Eggner's Ferry Bridge:

... when the C/M⁶ received his first instruction from the pilot to steer towards the green light of the 'E' span, through the time of the vessel's allision with the EFB,⁷ none of the crewmembers present upon the vessel's navigation bridge countermanded or challenged the pilot's instruction to steer toward the green light marking the center of the 'E' span.

As the vessel continued on its course, no attempt was made by the pilot, or the crewmembers to obtain a fix upon the vessel's position using other than visual means with the vessel's two spotlights. Per the SMS, the responsibility for obtaining vessel position fixes was the responsibility of the DWO who was not on the helm position, in this case, the 3/M.⁸ The SMS stated, 'the helmsman shall have no other duties when assigned to the helm,' and 'when the deck watch officer is acting as helmsman, a second deck officer and, or the master will be on the bridge to perform all other navigation and watch duties.'

Ultimately, the ship struck the lighted recreational span of the Eggner's Ferry Bridge on the east side of Kentucky Lake.



Screen capture from a cell phone video taken by a mate aboard the M/V Aiviq shows the tow wire on the right leading to the MODU Kulluk under tow. The computer screen on the left shows the readout in tons on the towing hawser (boxed in yellow) as 227 metric tons. The vessel's crew failed to recognize the importance of this critical measurement. U.S. Coast Guard image.

MODU *Kulluk* — The Investigation

On December 27, 2012, out in the Gulf of Alaska, the *Aiviq* was towing the *Kulluk* astern.⁹ Looking out the after wheelhouse windows, one of the mates on duty took a cell phone video of the seas and the *Kulluk* astern on the tow hawser. The video captured the hawser rising up from a somewhat slackened condition until it was almost horizontal to the deck of the *Aiviq*. It then led from the winch through the sea and swell, leading out to the *Kulluk* almost a quarter of a mile astern.

The downward deflection of the towing hawser is called catenary, which is one of the ways marine personnel assess towing operation safety. Correct use of this catenary absorbs the everyday stresses and strains of ocean towing, reducing the cyclic loading on critical equipment.

During the voyage, the *Aiviq*'s sophisticated towing winch strain gauge located in the wheelhouse showed the load on the towing equipment. In the cell phone video segment, the strain monitor showed the towing load swinging from 28 tons to 228 tons. The mate commented on the strength of the steel towing wire. From departure to the point where the towing equipment failed, there was near-continuous cyclic loading on the towing equipment.

In the late morning of December 27, 2012, the first in a series of towing gear failures occurred. There would be more gear failures as efforts took place to control the *Kulluk* in the extreme maritime weather environment of the Gulf of Alaska. At one point, the *Aiviq* suffered the loss of main engines, generator injector failures, and other issues with maneuvering thrusters while attempting to tow the *Kulluk*.

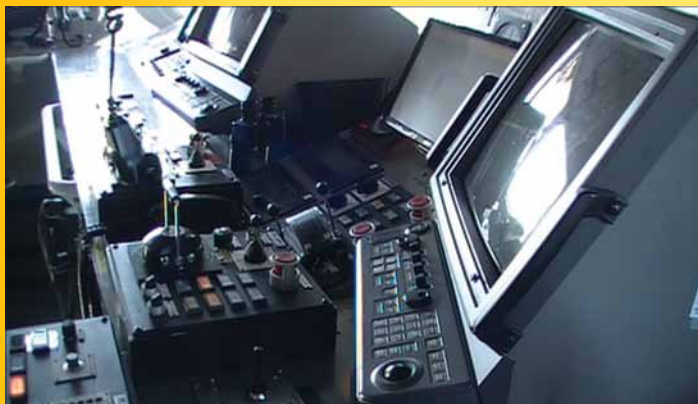
The Coast Guard investigation focused on, among other things, the SMS in place for the *Aiviq* and her crew as well

as the crew's training, competencies, and qualifications. The investigators looked for formal or informal policies, procedures, job aids, checklists, and other documentation indicative of how the unique towing operation was to be carried out.

Unfortunately, investigators were unable to uncover what constituted a safety management system related to towing operations. During the course of the investigation, it was determined that there was a disconnect as to the role and responsibilities for the towing vessel master and the tow master on the towed vessel *Kulluk*. A safety management system would have detailed the roles and responsibilities for these personnel, reducing ambiguity in the most critical moments.

Additionally, details on the use of the ultra-sophisticated towing winch, used to monitor and trend chart the load on the towing system and monitor the length of the towing hawser, were not discussed in the vessel's operating procedures. The tow system was equipped with alarms for critical events on the vessel, but bridge officers could not elaborate as to how the alarms and response to those alarms constituted a part of a comprehensive plan for towing the manned tow.

On the morning of the initial towing gear failure, there were 38 critical alarms for the towing winch system that indicated strains of at least 300 metric tons. The part that initially failed (or was lost) was a shackle with a safe working load of 125 tons. A robust SMS would have indicated how to handle these alarms or would have pointed the reader to the proper place where these strategies could have been found. Without going into all the deficiency elements of the towing operations, it would be appropriate to state that a robust and well-written SMS that incorporated lessons learned and



In the photo above, the bridge control equipment on the M/V *Delta Mariner*, and similar propulsion control equipment aboard the M/V *Aiviq* (right). Such complex, sophisticated equipment requires putting a comprehensive safety management system in place so the vessel's crew knows how to operate the systems under all kinds of expected conditions. U.S. Coast Guard photos.



appropriate risk assessment from previous towing voyages could have helped to mitigate the events that transpired on that voyage.

The *Aiviq* did have a safety management system in place, but the investigators could not find details for towing operations or anything directly related to towing operations. Specific written documentation addressing the safety for towing operations, such as voyage planning, towing speeds or routing, towing gear maintenance, roles and responsibilities, or inspections of equipment outside the ship-specific equipment were not addressed. This shortfall existed despite the fact that by custom and court interpretation, the towing vessel assumes complete responsibility for the safety of the tow once the towing hawser is connected.

Learning from the SMS Links

A robust and well-thought-out safety management system would have significantly reduced the risks in both of these incidents. In the case of the Eggner's Ferry Bridge allision, the NTSB report cites:

The passage plan provided inadequate information for safe navigation on the inland waters portion of the intended journey.

The bridge team overly relied on the direction of the contract pilot, despite his apparent uncertainty, which resulted in the bridge team attempting to maneuver the vessel under the incorrect span.

The contract pilot and the bridge team failed to effectively utilize all navigation tools, such as the electronic charting system and radar, as they approached Eggner's Ferry Bridge.

The [vessel's] safety management system was not effectively implemented on board the vessel at the time of the accident.

Focusing on just the towing operations for the *Aiviq*, a detailed safety management system covering towing operations, voyage route planning, vessel standing orders, use of towing strain monitoring equipment, and the role and responsibilities of bridge watch officers engaged in towing would have greatly reduced the chances of critical towing gear failure.

A vessel's safety management system is a critical safety component of vessel operations. As such, it needs to be well

developed, well understood, and, most importantly, well followed. To ensure the safety of people, the environment, and property, periodic reviews are necessary, as are attention to the lessons learned from previous operations and the changing risks associated with vessel operations.

Since the time of the NTSB investigation, it has been reported that the operating companies for the two vessels involved have critically assessed the accidents and have made a series of significant improvements related to their safety management systems and vessel operation policies.

About the author:

Mr. Keith Fawcett is a licensed mariner and a staff member at the USCG Investigations National Center of Expertise. He has worked in the marine industry for more than 20 years, has conducted several high-profile marine casualty investigations for the Coast Guard, and is one of the winners of the Sener Award for excellence in marine casualty investigations.

Endnotes:

- ¹ As the *Delta Mariner* Coast Guard investigation is ongoing, this article references the National Transportation Safety Board (NTSB) final report "Allision of the Cargo Vessel M/V *Delta Mariner* with Eggner's Ferry Bridge, Tennessee River Near Aurora, Kentucky January 26, 2012 Accident Report NTSB/MAR-13/02" as the basis for its analyses and conclusions. Please note that any section in italics indicates information directly quoted from this report, which can be found at <http://dms.nts.gov/pubdms/search/document.cfm?docID=395429&docketID=52354&mkey=82752>.
- ² According to the same NTSB report mentioned above, the owner of the *Delta Mariner* regularly hired experienced towing vessel masters to guide and assist the bridge team for the portion of its inland rivers route between Decatur, Alabama; and Baton Rouge, Louisiana. For the purposes of this report, these individuals are referred to as contract pilots. They were not federally or state-licensed pilots, but they held Coast Guard-issued master of towing vessel licenses.
- ³ From the NTSB report, "Navigation lighting on Kentucky bridges" section, page viii. Given that Eggner's Ferry Bridge was not properly lit on the night of the accident, the NTSB investigated the maintenance of lighting on Kentucky bridges crossing navigable waterways. The investigation found that the Kentucky Transportation Cabinet (KYTC), the owner of the bridge, failed to effectively maintain the bridge's lighting in accordance with the Coast Guard-approved lighting plan. The KYTC also did not identify and resolve recurring lighting problems and their causes. The NTSB found that the personnel in the division performing repairs relied on inadequate knowledge of the correct lighting configuration, and that the KYTC's oversight of its bridge navigation lighting maintenance was ineffective.
- ⁴ MODU *Kulluk* investigation.
- ⁵ Deck watch officers.
- ⁶ Chief mate.
- ⁷ Eggner's Ferry Bridge.
- ⁸ Third mate. There were two licensed officers on the bridge. Due to the unique design of the vessel and the propulsion system, only licensed officers actually steered the vessel through this segment of the waterway.
- ⁹ Facts and chronology from the U.S. Coast Guard report "Report of the Investigation Into the Circumstances Surrounding the Multiple Related Marine Casualties and Grounding of the MODU *Kulluk* on December 31st, 2012," found at www.uscg.mil/hq/cg5/cg545/docs/documents/Kulluk.pdf.

Suspension and Revocation for Safety Management System Violations

Maintaining standards for competence and conduct
essential to safety at sea.

by CDR CHRISTOPHER F. COUTU
Chief
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The benefits of shipboard safety management systems (SMSs) are myriad—a crew’s conduct and adherence to vessel operation procedures at sea can mean the difference between a safe, profitable voyage and one resulting in disaster. While safety management systems are generally required for large oceangoing vessels involved in foreign trade, smaller vessels and domestic companies have implemented them to identify—in one location—the important company policies, practices, and procedures a ship’s crew is expected to follow to ensure a safely functioning vessel.

Safety management systems help ensure that ship personnel comply with mandatory safety rules and regulations

and also follow codes, guidelines, and classification society requirements as well as concerned maritime organization parameters. In short, the SMS establishes a standard of conduct, encapsulates shipboard policies, and defines the rules governing safe ship operation.

In the Coast Guard world of mariner license suspension and revocation (S&R), the SMS can provide a standard upon which the conduct of a mariner is judged—the backbone upon which the body of an investigation may be formed and ultimately enforced.

License Enforcement Backdrop

Before we delve into how safety management systems fit within the construct of a potential S&R action, a bit of background. The privilege of sailing on American vessels is contingent upon possessing a merchant mariner credential (MMC or “credential”). Congress charged the Coast Guard with vetting prospective mariners and issuing MMCs to qualified individuals.¹ These documents serve as occupational licenses—a mariner’s “ticket” to a career at sea. Along with requiring mariners to hold a credential to serve aboard vessels in specific capacities, Congress also charged the Coast Guard with disciplining the same mariners by way of suspending or even revoking credentials through suspension and revocation actions on the credential itself.

The necessity for federal oversight was born out of a string of maritime tragedies. For example, in 1832, about 14 percent of steam vessels in operation had been



LTJG Stephanie Kurucar of Coast Guard Sector New Orleans reviews crew credentials and licenses. U.S. Coast Guard photo by Petty Officer Casey J. Ranel.

destroyed by explosion, with a loss of life exceeding 1,000. Then, between 1847 and 1852, a series of disasters primarily caused by boiler explosions occurred, in addition to others caused by fires and collisions.²

In response, Congress passed the Steamboat Act of 1852, which allowed federal action on mariners and made owners and masters liable for damages resulting from failure to employ properly trained engineers. Under this law, the organization and form of a federal maritime inspection service began to emerge, as it empowered inspectors to grant and revoke pilots' and engineers' licenses.

This early system was supplanted and made more robust by the Act of 1871,³ which formed the Steamboat Inspection Service. This act provided for licensing for masters and chief mates. It also made S&R actions into a more formal process, requiring written notice and hearings. The Coast Guard's current licensing enforcement structure is founded upon this rich history.

S&R Structure

The Coast Guard's National Maritime Center (known as "the NMC") issues credentials to merchant mariners. Coast Guard officers in charge of marine inspection (OCMIs) in each port have the authority to issue complaints against those credentials for various violations; however, they do not have the authority to suspend or revoke a credential. That burden rests with the Coast Guard's cadre of six administrative law judges, who are charged with this duty under the grounds set out in 46 U.S.C. §§7703 and 7704. S&R proceedings are conducted under the Administrative Procedure Act,⁴ which ensures that mariners' due process rights are safeguarded.

Mariners may appeal administrative law judge decisions to the Commandant. They may also appeal directly to federal district court if, for example, the judge orders something other than suspension or revocation. If a mariner is unhappy with the outcome of an appeal to the Commandant, he or she may appeal that decision to the National Transportation Safety Board, and then to the United States Court of Appeals, if still unsatisfied.

On average, 500 complaints a year are filed against mariners. Suspension and revocation regulations are constructed to obtain a just, speedy, and economical determination of the issues presented. Additionally, the administrative action against a merchant mariner's credential is remedial and not penal in nature. In keeping with its historical roots, the Coast Guard's actions are intended to help maintain standards for competence and conduct essential to safety at sea. In short, Congress demands a safer maritime community by way of action on licenses,⁵ and the Coast Guard seeks to

accomplish this mission through its suspension and revocation program.

S&R Triggers that Relate to SMS

Without belaboring all the permutations of offenses and mariner infractions that might trigger a suspension and revocation action,⁶ the most notable of all violations is drug use. Approximately 70 percent of the 500 complaints filed each year against mariners involve some variation of drug offense. The rest of the complaints are largely composed of allegations of misconduct or negligence.

Misconduct: This is mariner behavior that violates an established rule, such as those found in statutes, regulations, the common law, the general maritime law, a ship's regulation or order, or shipping articles. In addition, the Coast Guard has long held that company policy with regard to crew conduct relative to safety matters aboard the ship is a good norm for judging misconduct; they have successfully prosecuted numerous complaints against mariners for violating their company's policy.⁷

Negligence: In civil law, prosecutors must prove several elements of negligence to find liability: that a duty exists, the duty was breached, and the breach was the cause of resulting damages. However, to trigger Coast Guard S&R action, the Coast Guard must only show that the mariner had a duty and that he or she breached the duty.⁸ The lack of a damage element makes good sense in the world of S&R actions, as the Coast Guard seeks to prevent accidents and improve mariner conduct to support marine safety.

Safety Management Systems as a Basis for License Action

Safety management systems fit into the S&R construct because they were developed for the very reason suspension and revocation actions exist—to promote safe ship operation. Some shipping companies are required to produce a safety management system by way of the International Convention for the Safety of Life at Sea (SOLAS) and U.S. implementing regulations. Others produce safety management systems because they seek to standardize safe shipboard operations and establish a standard of care for their vessels.

Suspension and revocation action is applicable whether a safety management system is required or not, depending on the policy or procedure violated. When a ship adopts policies and procedures relating to vessel safety, they, in turn, establish shipboard regulations and create the company policy against which a mariner's actions may be compared.

According to a Commandant Decision on Appeal, company rules are standards upon which to measure mariner conduct. The Commandant has held: "A company's policy for

maintenance of order and good safety conditions aboard a vessel, governing the conduct of the crew, is precisely the kind of rule that does establish standards for the invocation of the 'misconduct' provision [for S&R proceedings]."⁹

In addition to misconduct charges, possible S&R enforcement could also be triggered for negligence, as the SMS may establish a standard of care that a prudent mariner is expected to follow—a breach of which, even without a casualty, could result in allegations being issued.

Getting It Right

In summary, the SMS is a set of company policies and rules, and the policies are a good norm for judging misconduct. To trigger negligence for S&R action, the Coast Guard must only show that the mariner had a duty and that he or she breached the duty.¹⁰

All this may cause some mariners angst. Safety management systems can be vast, with so many rules and procedures that it may seem impossible to remain compliant to all provisions. The thought of S&R action stemming from such a broad set of rules is daunting.

The Coast Guard is limited, however; it can't tie just any SMS violation to a suspension and revocation action. Each situation is dependent upon the policy violated and whether it was directly related to safety aboard the ship in the particular situation investigated. Additionally, the Coast Guard doesn't take its S&R responsibilities lightly—action upon the license could mean a potential loss of livelihood. To a mariner who depends upon supporting a career and earning a paycheck while working at sea, losing a credential has a serious impact, even if only on hold for a short while.

But, just as it's important that the Coast Guard gets these cases right, due to the impact on mariners' livelihoods, it's also important for the credentialed fleet to know the bounds of the Coast Guard's authority. To steer clear of possible S&R enforcement, a credentialed mariner should do his or her part to ensure a safely functioning vessel by staying up-to-date on either the company's safety management system rules (if there is a formal SMS) or on the company's policies (if no formal SMS exists), *especially as they pertain to safety aboard the ship*. Violations of SMS rules and shipboard regulations can invoke jurisdiction over their Coast Guard-issued credential.

About the author:

CDR Christopher F. Coutu is the chief of the Suspension and Revocation National Center of Expertise. He is a 1993 graduate of the University of Rhode Island and a 2001 graduate of Suffolk University Law School. He has served for 14 years in the Coast Guard in legal and prevention positions.

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Statistics courtesy of the U.S. Coast Guard Suspension and Revocation National Center of Expertise.

Endnotes:

- ¹ See generally 46 U.S.C. Subtitle II, Part E.
- ² U.S. Steamboat Inspection Service & the History of Merchant Vessel Inspection. See www.uscg.mil/history/articles/Steamboat_Inspection_Service.asp.
- ³ 16 Stat. 447 (1871). See also "Improving Competence in the Merchant Marine: Suspension and Revocation Proceedings," Eugene R. Fidell, *Missouri Law Review*, Vol. 45, Winter 1980 *referencing* H. Bloomfield, *Compact History of the United States Coast Guard* 263–65 (1966).
- ⁴ 5 U.S.C. §§ 551-557. See also 46 U.S.C. § 7702(a).
- ⁵ See 46 U.S.C. § 7701.
- ⁶ For a more detailed article on this subject, please see "Mariners Can Lose Credentials for What?," *Proceedings*, Winter 2015-16, p. 53-56, at <http://uscgproceedings.epubxp.com/t/11313-proceedings-of-the-marine/55>.
- ⁷ Appeal Decision 1567 (CASTRO) (1966).
- ⁸ See Appeal Decision 2539 (HARRISON) *citing* Commandant v. Wardell, NTSB Order EM-149.
- ⁹ Appeal Decision 1567 (CASTRO) (1966).
- ¹⁰ See Appeal Decision 2539 (HARRISON) *citing* Commandant v. Wardell, NTSB Order EM-149.

Putting People at the Center

Integrating human factors into safety management systems.

by Ms. DAWN M. GRAY
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Integrating human factors into a safety management system (SMS) allows a company to identify and analyze relevant human factors issues, then apply appropriate tools, methods, and measures to address those issues.

For example, effectively integrating human factors elements into a safety management system can:

- improve staff effectiveness and well-being;
- facilitate appropriate allocation of human resources;
- contribute to an overall safety culture;
- improve training process effectiveness;
- decrease costs from redesign activities;
- improve equipment usability;
- provide information that improves safety performance, which reduces risk and improves SMS effectiveness.

This all results in the goals of optimizing performance, increasing efficiency, and reducing costs.

So—what are these “human factor” elements? They can be grouped into three main categories:

- the individual,
- the job,
- the organization.

The individual: Elements related to the individual (see Table 1) include factors associated with people at all levels of an organization—from the head of a company to the seafarer at the deck plate—with regard to their culture, skills, personality, motivation, physical build, and risk perception. While some characteristics are fixed, such as personality, physiology, and physical build; other characteristics such as knowledge, skills, and attitudes can be changed or improved.

The job: Elements related to the job (see Table 2) are associated with working conditions and job design, including the work environment, stress, work schedule, task type, workload, control and display design, and procedures. As such, companies should design tasks to take account of the physical and mental strengths and limitations of the people performing the job.

The organization: Elements related to the organization (see Table 3) consist of the policies, procedures, and methods that affect the design of the job, including aspects related to the organizational culture, training, manning, leadership, safety culture, training management, personnel selection, and retention.

Feedback Loop for Safety Performance Improvement

How do human factors affect the deck plate level? Incorporating human factors elements into a safety management system may optimize personnel performance. These

Table 1: Individual Elements

Ability and Behavior	Person-Related Conditions
✓ Knowledge/competence/attitude	✓ Personality
✓ Skills	✓ Capabilities (physical and mental)
✓ Fitness/health	✓ Risk perception
✓ Experience	✓ Decision-making capabilities
✓ Communication skills	✓ Confidence
✓ Languages	✓ Workload management
✓ Listening skills	✓ Culture, beliefs, and values
✓ Motivation	✓ Stress
✓ Fatigue	

Adapted from: European Railway Agency, Application guide for the design and implementation of Railway Safety Management System: Integrating Human Factors in SMS, ERA/GUI/10-2013/SAF V 1.0, 2013.

Feedback Loop for Safety Performance Improvement



Therefore, it's important that organizations integrate human factors into the elements of a safety management system that deal with the following feedback loop elements:

- risk management;
- change management;
- systems, equipment, and machinery design;
- task and job design;
- safety-critical personnel selection and training;
- safety reporting and data analysis;
- incident investigation.

Risk management: Organizations should consider all people who interact with the system, estimate foreseeable noncompliance with standard operating procedures, note abnormal or infrequent modes of operation, and recognize how fatigue can relate to risk. Control measures for potential human error should focus on equipment design and usability; task and job design; and workplace design, procedures, training, communication, teamwork, supervision, and monitoring. The most effective human error control measures either remove or modify the hazard.

elements form a feedback loop that organizations can mine for sources and potential for human error. Personnel can then address these through the SMS risk management process.

Change management: Integrating human factors into the change management process minimizes potential risks by considering the impact of the change to the people within the system. Further, change has the potential to introduce

new human factor issues or even worsen existing issues, since changes in machinery, equipment, technology, procedures, work organization, and work processes are likely to affect human performance.

Systems, equipment, and machinery design: Designing and modifying human machine interfaces such as control systems, alarms, warnings, and automation within a system may involve significant human factors risks. The most effective way to manage this risk is to integrate human factors and usability principles in the early design stages.¹

Table 2: Job Elements

Job Design	Design of Interface/ Equipment	Environment	Rules and Procedures
<ul style="list-style-type: none"> ✓ Number and nature of tasks ✓ Complexity ✓ Repetitiveness ✓ Delegation of duties ✓ Rules/ instructions ✓ Workload ✓ Team management ✓ Team spirit ✓ Group influence ✓ Feedback ✓ Corrective actions 	<ul style="list-style-type: none"> ✓ Workplace layout ✓ Ergonomic design of equipment ✓ Usability of equipment ✓ Feedback ✓ Quality of equipment ✓ Inspection/ maintenance ✓ Management of information ✓ Presentation of outcome 	<ul style="list-style-type: none"> ✓ Temperature ✓ Noise ✓ Illumination ✓ Cleanliness ✓ Ventilation ✓ Weather conditions ✓ Wind ✓ Humidity ✓ Vibrations ✓ Dangerous substances ✓ Dangerous energy (i.e. thermal, electric) ✓ External dangers 	<ul style="list-style-type: none"> ✓ Content and relevance ✓ Flow ✓ Scope ✓ Interfaces ✓ Validity ✓ Adequate and comprehensive awareness ✓ Effort needed ✓ Emergency performance ✓ Flexibility ✓ Consultation w/staff ✓ Testing period ✓ Revision ✓ Change management

Adapted from: European Railway Agency, Application guide for the design and implementation of Railway Safety Management System: Integrating Human Factors in SMS, ERA/GUI/10-2013/SAF V 1.0, 2013.

Predicting System-Specific Human Factors Risks

All of the human factors elements presented can positively and negatively influence the risk of human error. Human Reliability Analysis (HRA) is a useful methodology that can help predict system-specific human factors risks.¹

What is HRA?

Human reliability is the probability that people will perform as required for the specified time and environmental conditions. Human reliability analysis provides methodologies which can quantify human performance-related risks for a specific system design. Several HRA methods are identified in the table below:

HRA Methodology	Description
Human Factors Process Failure Modes and Effects Analysis (HF PFMEA)	Qualitative technique used to identify potential human errors, error types, error contributing factors, and consequences of error.
Technique for Human Error Rate Prediction (THERP)	Comprehensive analysis technique used to perform preliminary task analysis and to estimate human error probabilities. Vessel/facility-specific and event-specific information is obtained.
Human Error Assessment and Reduction Technique (HEART)	Simple technique with available data based on ergonomics and performance research. Error-producing conditions are obtained to calculate human error probability.
Cognitive Reliability and Error Analysis Method (CREAM)	Flexible technique that uses task analysis, assessment of performance influencing factors, and performance context to estimate human error probability.

How It Works

The HRA process involves problem identification, task analysis, error identification, error modeling, quantification, and integration into risk assessment. Problem identification includes defining:

- 1) who is interacting with the system (and their mental and physical abilities);
- 2) system configuration being analyzed (i.e. hardware and software); and
- 3) environmental operating conditions.

Human reliability calculations are used to estimate frequencies or probabilities in risk models.

Based on a system's individual, job, and organizational human factors elements, using HRA techniques can help identify the type of human errors that can occur within a system design, quantify how likely it is the identified errors will occur, and help companies reduce those calculated likelihoods.

All of these factors can show a company where it is vulnerable to human error. The company can then use SMS elements to reduce operational risks and minimize associated consequences through mitigation, planning, and monitoring processes.

How Maritime Companies Can Learn More About HRA

Literature on HRA is available from many different sources, some of which include those cited here:

- A.J. Spurgin, Human Reliability Assessment Theory and Practice, 1st Edition, 2009.
- B. Kirwan, Practical Human Reliability Assessment, Taylor & Francis, 1994.
- B.S. Dhillon, Human Reliability and Error in Transportation Systems, 2007.
- Human Reliability Analysis Methods Selection Guidance for NASA, 2006 edition.

Additionally, some maritime consulting companies employ experts in HRA and offer HRA services as well as other human factors analysis services for identifying and mitigating human error opportunities.

Endnote:

- ¹ B. Kirwan, Practical Human Reliability Assessment, Taylor & Francis, 1994.
- ² Human Reliability Analysis Methods Selection Guidance for NASA, 2006 edition.

Task and job design: Improving job, task, and workspace design can provide significant improvements in human performance. Further, ensuring that tasks and activities are appropriately suited to the operator's or team's capabilities and limitations can significantly reduce human error risk. For example, tasks can negatively impact human

performance if they involve excessive time pressure, complex sequences of operations, reliance on memory, or are physically or mentally fatiguing. It is important to identify performance objectives up front that organizations can use to evaluate safety performance when designing task sequences and actions for safety-critical tasks.

Table 3: Organizational Elements

Work Patterns	Management	Communication	Competence Management	Supervision
<ul style="list-style-type: none"> ✓ Structure and task allocation ✓ Resources ✓ Information 	<ul style="list-style-type: none"> ✓ Leadership ✓ Roles and responsibilities ✓ Change management ✓ Safety culture ✓ Learning organization ✓ Continuous improvement spirit 	<ul style="list-style-type: none"> ✓ Structure ✓ Flow ✓ Internal ✓ External 	<ul style="list-style-type: none"> ✓ Recruitment process ✓ Competencies/skills ✓ Training programs ✓ Methods ✓ Re-examination of task requirements ✓ Competency verification ✓ Performance monitoring 	<ul style="list-style-type: none"> ✓ Monitoring ✓ Lessons learned ✓ Management review ✓ Continuous improvement

Adapted from: European Railway Agency, Application guide for the design and implementation of Railway Safety Management System: Integrating Human Factors in SMS, ERA/GUI/10-2013/SAF V 1.0, 2013.

Safety-critical personnel selection and training: It is important to identify and assure that people who perform safety-critical functions are adequately trained. First, of course, you have to hire them, so it's important to identify the related knowledge, skills, and attitudes that are needed to perform a specific role or job. Once organizations define the job competencies, personnel must develop methods to select and train people based on these competencies. Further, organizations should evaluate current employees to ensure each has the appropriate competencies, and, if not, personnel should implement training to bridge any discernible gaps.

Safety reporting and data analysis: The main objective of any safety data collection and analysis system is to make events, hazards, safety trends, and their contributing factors visible, understandable, and supported by usable data so that effective corrective action can be taken. The behavior of people involved in incidents or near-misses may not differ significantly from that observed when accidents occur. Cognitive failures, poor decision making, communication breakdowns, distractions, and all other factors contributing to accidents will also be present in near-misses. Because of this, it is important that a safety management system reporting system identifies contributing human factors, and that personnel within the company are trained and encouraged to identify and report them.

Incident investigation: When accidents and incidents occur, it is essential that the company properly investigates how human factors may have contributed to the situation. The human factors component of investigation should be based on a framework for systematic investigations, considering human error from the individual and organizational levels. This requires that investigators be trained in basic human factors concepts, and organizations should design

procedures to examine the detail of human performance factors that may have contributed to the event.

Optimizing Overall Performance

Integrating human factors elements into a safety management system provides a company a framework to optimize overall performance throughout a system lifecycle. While this method cannot completely eliminate the natural hazards associated with operating in an often harsh and unforgiving maritime environment, implementing an SMS that integrates human factors reduces the risk to people, equipment, and the environment.

About the author:

Ms. Dawn M. Gray has been serving the U.S. Coast Guard since 2011. She manages human factors considerations in policy, regulation, and standards. Previously, she provided human factors oversight and support for projects across the Coast Guard fleet. Ms. Gray has an MA in human factors and applied cognition, and is a certified human factors professional.

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U.S. Department of Transportation Federal Railroad Administration, 2003. Human Reliability Analysis in Support of Risk Assessment for Positive Train Control, DOT/FRA/ORD-03/15.

Y. Jianxing, X. Zunwu, and F. Mingyang, 2014, Quantitative Human Reliability Analysis for Crew During Shipping Operation. Transactions of Tianjin University, 20:5, 375-378.

J. Reason, Human Error, Cambridge, U.K.: Cambridge University Press, 1997.

Endnote:

¹ Industry standards such as ASTM F-1166-07 Standard Practice for Human Engineering Design for Marine Systems, Equipment, and Facilities; ASTM 1337-10 Standard Practice for Human Systems Integration Program Requirements for Ships and Marine Systems, Equipment, and Facilities; ANSI/HFES 100-2007 Human Factors Engineering of Computer Workstations; and ANSI/HFES 200 Human Factors Engineering of Software User Interfaces are useful sources for system and human machine interface design guidance.

Lessons Learned

from USCG Casualty Investigations

In this ongoing feature, we take a close look at recent marine casualties. We outline the U.S. Coast Guard marine casualty investigations that followed, which explore how these incidents occurred, including any environmental, vessel design, or human error factors that contributed to each event.

Article information, statistics, conclusions, and quotes come from the final, promulgated Coast Guard investigation report.



Deadly Fun

Personal watercraft operating dangers.

by Ms. SARAH K. WEBSTER
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Public Affairs Specialist
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On May 30, 2010, a woman went out on the Ohio River with a personal watercraft for some fun. Instead, she lost her life after crossing paths with a vessel and its tow.

On September 28, 2013, a man and a woman rented a personal watercraft for a tour. The male driver, who had little experience in properly operating a personal watercraft, made a hard turn right into the center tunnel of a tour boat's catamaran hull—ultimately ejecting both riders from the personal watercraft and into the water. Both died from the collision.

Operator inattention, improper lookout, operator inexperience, excessive speed, and machinery failure rank as the top five primary contributing factors in recreational boating accidents.¹

Story 1: A Day on the River

On a Sunday afternoon over Memorial Day weekend, a group of three arrived at a riverboat ramp with a personal watercraft (PWC). The group launched the personal watercraft with all three aboard, then headed toward a beach approximately 2.5 miles downriver. They arrived about five minutes later and dismounted the PWC to enjoy some recreation on the beach.

Around the same time, the mate of an uninspected towing vessel (UTV) relieved the navigation watch and prepared to get underway with a tow configuration totaling approximately 1,128 feet. While traveling upbound with a 14-barge tow, the mate acted as the sole lookout from the wheelhouse.

Approximately an hour later, one woman from the personal watercraft trio asked the owner if she could ride the recreational vessel solo. The owner said, yes, she could, but that two friends were back at the boat ramp awaiting a ride to the beach. The woman agreed to pick up the friends and was last seen aboard the PWC traveling upbound at a high rate of speed.²

The PWC operator set her vessel on a parallel course to the uninspected towing vessel, moving at 50 to 70 miles per





The tow and tow vessel. U.S. Coast Guard photos.



A wheelhouse view of the tow.



Damage to the personal watercraft (story 1).

hour, and she soon overtook the UTV and its tow, crossing its trackline.

Somehow, the woman either fell or was ejected from the personal watercraft. A Coast Guard marine investigator and boating accident investigator used evidence and testimony to piece together the woman's final hours. According to the report of investigation, it's suspected that she engaged the bow wake of the tow being pushed upriver at a high rate of speed. The reaction of the PWC at the point of engagement with this wake was unpredictable and dependent on the operator's inputs, such as throttle control and weight distribution, leading investigators to believe that the operator lost control of the personal watercraft, sustained an incapacitating injury, and fell from the personal watercraft directly in front of the tow.

The river current then carried the personal watercraft and the woman in front of the head of the tow, where both collided with an empty tank barge. The tank barge was positioned at the head of the port string of barges being pushed ahead by the tow vessel. The PWC soon emerged on the tow's port side.

According to testimony, the mate aboard the UTV never saw the personal watercraft with the operator aboard, nor did he see the PWC overtake his vessel. Once the PWC surfaced, another crewmember aboard the towing vessel reported it to the mate and advised him there was no operator aboard, nor did he see anyone in the water. He also reported he didn't see any visible signs of damage to the watercraft, though investigators later discovered damage to its port side—cracked fiberglass, transfer/scratches on the cowling port/forward.

It wasn't until more than three hours later that the personal watercraft operator surfaced. She was wearing a lifejacket and floating in between the first and second barges of the port string of barges in tow. The deckhands aboard the towing vessel retrieved the woman and presumed her deceased as a victim of drowning. They placed her in blankets, covered her, and prayed. Emergency medical services arrived on the scene shortly thereafter, boarded the tow, and confirmed no signs of life. Medics transported the victim ashore for medical evaluation, identification, and next-of-kin notification.

Personal Watercraft Data: A Five-Year Study (2009–2013)

Each year, the Coast Guard receives reports of accidents that occur on U.S. waterways. Personal watercraft safety is a hot topic for good reason, as indicated by the following findings:

- Personal watercraft account for roughly one-fifth of the vessels involved in these accidents, ranking second behind open motorboats.
 - There are roughly 1,000,000 PWCs registered in the U.S., which is 9 percent of motorized vessel registration and less than 5 percent of the overall number of recreational vessels.
 - Deaths on PWCs represent 6.5 percent of deaths; injuries on PWCs make up 24.5 percent of injured victims.
- Collisions with other vessels are common accident occurrences; roughly 60 percent of all personal watercraft involved in accidents occur in this manner. Many times, PWC operators fail to keep a proper lookout, and quite frequently, two or more personal watercraft operators loop around each other playfully at high speeds. When one operator turns sharply and lets off the gas, a shield of spray hinders the other's ability to see well. With this lack of visibility, the other operator doesn't know to take evasive action, leading to a crash.
- Many other collisions are caused by inexperience. Many PWCs do not allow the user to steer the boat without the throttle engaged; consequently, if an operator sees that a crash is imminent, often his or her gut reaction is to let off the throttle and turn. However, when the operator lets off the throttle, he or she usually loses steering ability, and the vessel continues in the same direction as before, often crashing into the thing the operator was trying to avoid. Luckily, many new personal watercraft are designed to provide the operator with steering ability even if he or she chooses to let off the throttle.
- Falling out of the boat, either by force (for example, when a wave hits a boat) or by gravity, is another common occurrence involving PWCs. Roughly one out of every six personal watercraft involved in an accident had someone either forcibly ejected from the boat or someone who fell off the boat as the first event in the accident. Oftentimes, a person will suffer an injury from impacting the handlebars after hitting a wave, or suffer an injury from getting a foot stuck while being ejected. Very rarely, serious internal injury can occur when a person falls off the back of the PWC and into the path of its high-pressure water jet.
- There have been an average of 44 deaths a year on PWC. Trauma is the most frequently listed cause of death, accounting for more than half of this number.
- There have been more than 700 injured victims a year on PWCs. Common injuries include broken bones, cuts, bruises, concussions, and sprains/strains.
- Personal watercraft operators range in age from preteens to senior citizens approaching their 80s. The average age of operators involved in PWC fatalities is 37 years old. The average age of operators sustaining injuries in nonfatal accidents is 31 years old.
 - In fatal and nonfatal injury accidents, the average age of PWC operators (37 and 31, respectively, as described in the bullet above) was much lower than the average age for all boats combined. The average age of operators in fatal accidents was 46; 39 years old was the average for nonfatal accidents. Houseboat and sailboat operators had the highest average age of operators, and for both fatal and nonfatal accidents, 50-plus was the average age of operators on these craft.
 - The average age of deceased PWC victims is 35 years old. The average age of injured victims on personal watercraft is 28 years old, which is much lower than the average age of victims on all boats combined. The average age of a deceased victim is 44 years old, and the average age of an injured victim is 34 years old.

Bibliography:

For more information on online data search abilities, visit <https://bard.cns-inc.com/Screens/PublicInterface/Report1.aspx>.

Story 2: Excursion Gone Wrong

On Saturday, September 28, 2013, a man and a woman rented a personal watercraft around 5:45 p.m. in Clearwater, Florida, as part of a "One-Hour Free Play" package. During the excursion orientation, the man said he'd had experience operating a personal watercraft in India. The renters put on

personal flotation devices, and the rental company provided an orientation detailing the proper operation of the vessel and a description of the tour. The man and woman then left the marina, led by a tour guide who was on a separate personal watercraft.

PWC Manufacturing Safety Developments

Some personal watercraft manufacturers have developed additional features to help protect riders.

Off-throttle steering (OTS) allows PWC operators greater maneuverability when off throttle or off power. Prior to the introduction of OTS, operators would often lose the ability to steer the PWC without the throttle engaged.

Braking systems allow the operator to bring the PWC to a controlled stop on demand. Prior to the introduction of braking abilities, an operator would have to disengage the throttle and coast to a stop.

Both of these developments have undoubtedly prevented collisions and allisions.

The PWC operators were transiting to the designated “free play” area. Once the vessels cleared the marina’s no-wake zone, the tour guide checked with them to see if they were ready to increase speed and proceed by following him to the designated area. Both PWCs increased speed; however, the rental operator released the throttle shortly after getting the vessel up on plane.

The tour guide circled back to assess whether the operator was in control of the vessel and to confirm once again that they were ready to continue. After receiving this confirmation, the tour guide accelerated and proceeded southeast on the causeway channel across the intersection of the Bird Island Shortcut Channel. At the same time, a tour vessel approached the intersection via the shortcut channel from the south.

The rental operator followed the tour guide down the causeway channel, but his own vessel’s course made a slight arching turn to starboard in the direction of the tour boat. Observing the irregular behavior of the rental operator’s personal watercraft, the tour boat’s master declutched the vessel’s engines, but momentum continued to carry the tour boat forward.

The operator of the rented personal watercraft seemed to identify the threat of collision. Video evidence reveals that he made a series of throttle adjustments over a period of 1.9 seconds, as indicated by the intensity level of the water propulsion discharge. He applied throttle, lessened or released throttle, and then applied throttle just a few seconds—and a few feet—prior to impact.



Damage to the personal watercraft (story 2). U.S. Coast Guard photo.

At the point of extremis and with significant throttle, the PWC operator made a hard turn to starboard and collided into the center tunnel of the catamaran hull of the tour boat. Both riders’ bodies impacted the deck and port hull of the tour boat, ejecting them from the personal watercraft.

Their bodies surfaced off the stern of the tour boat, unresponsive. The PWC tour guide recovered both victims and transferred them to the tour boat, where some of the vessel’s passengers and crew, including a fire rescue first responder, began CPR. The victims were ultimately transported back to the shore, where they were pronounced dead.

Post-casualty assessment and witness testimony indicate that the personal watercraft involved in the incident was in sound mechanical condition prior to the collision, and that mechanical failure did not appear to be a causal factor.

Lessons Learned

Story 1: A Day on the River

The woman aboard the personal watercraft had no boating safety training and likely no knowledge of the “rules of the road.” She most likely made the decision to overtake the tow to reach the flat, calm water in front of the tow. However, the speed of both vessels as well as the bow wake from the head of all tows present elements that all vessel operators must consider before overtaking a tow and tow vessel.

Moreover, the mate/pilot aboard the uninspected towing vessel was fatigued the day of the incident. His employer had transferred the mate from one vessel to another, which resulted in fragmented sleep the morning of the collision. The pilot only slept for approximately three hours the previous night, versus the five and a half hours he had grown accustomed to the three days before that. He’d also had a

five-hour van ride prior to becoming the operator and sole lookout of the towing vessel. While western rivers tow vessel operators commonly operate as the steersman as well as their own lookout, this incident occurred over Memorial Day weekend, when recreational vessel traffic on the waterway was known to be heavy.

Story 2: Excursion Gone Wrong

The watercraft operator on the rental lacked the boating skills required to operate a personal watercraft effectively.

According to witness testimony, the man who rented the PWC indicated he had operated one in the past, but the extent of that experience was suspected to be limited and not recent. In situations where an inexperienced PWC renter may have to pass through a heavily navigated channel, a check ride in an isolated area is recommended.

Further, Florida law requires PWC liveries to provide an on-the-water demonstration and check ride to evaluate renter proficiency. The PWC rental company personnel may have believed they met this requirement by requiring a guide to instruct and escort all renters. However, with the business' location set in a busy marina, renters were immediately exposed to high levels of commercial and recreational traffic before they could demonstrate or learn vessel proficiency.

In this situation, the rental company did provide an orientation describing PWC controls, characteristics, and handling. However, until they actually climb aboard a PWC and get

adequate practice, new and less experienced operators don't get the hands-on experience necessary to learn how the vessel will react to throttle and steering changes.

Personal watercraft are unique, in that throttle is usually necessary to steer the vessel. This characteristic is often covered in new rider orientations and helps to explain why the PWC operator continued to increase the throttle application as he attempted to steer out of the situation.

Acknowledgments:

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Endnotes:

- ¹ 2013 *Recreational Boating Statistics*. U.S. Department of Homeland Security, U.S. Coast Guard Office of Auxiliary and Boating Safety, COMDTPUB P16754.27, 2014.
- ² Note: At 60 miles per hour, a personal watercraft can travel 1,000 feet in approximately 13.6 seconds, and a half-mile in 30 seconds.



Nautical Engineering Queries

Prepared by NMC Engineering Examination Team



1. Which of the following actions must be carried out before a voltage tester can be used to test the three line fuses to a three-phase motor?
 - A. The fuses must be removed from the circuit.
 - B. The starter must be placed in the STOP position to stop and disconnect the motor.
 - C. The three line connections in the motor terminal box must be disconnected and tagged.
 - D. Nothing need be done as long as the motor is running under a light load.

2. The instrument always used in conjunction with a salinometer is a _____.
 - A. pyrometer
 - B. thermometer
 - C. hygrometer
 - D. hydrometer

3. Which of the listed diesel engine starting systems is most susceptible to difficulties in cold weather?
 - A. direct cylinder admission air start
 - B. hydraulic
 - C. electric
 - D. air motor starting

4. The formation of a pit in a boiler tube is most likely to occur when _____.
 - A. waterside deposits are present
 - B. sludge is present
 - C. dissolved oxygen is present
 - D. the tube metal acts as a cathode

The banner features a collage of nautical images: a sextant on the left, a radar display in the center, and coiled rope on the right. The title 'Nautical Deck Queries' is written in a large, white, stylized font over the left side of the collage.

Nautical Deck Queries

Prepared by NMC Deck Examination Team

Q

uestions

1. **BOTH INTERNATIONAL & INLAND:** Which vessel would sound a fog signal consisting of the ringing of a bell for 5 seconds?
 - A. a vessel engaged in fishing, at anchor
 - B. a vessel restricted in its ability to maneuver, at anchor
 - C. a sailing vessel, at anchor
 - D. all of the above

2. You are en route to assist vessel A. Vessel A is underway at 6 knots on course 133°T, and bears 042° at a range of 105 miles. What is the course to steer at 10 knots to intercept vessel A?
 - A. 063°
 - B. 068°
 - C. 073°
 - D. 079°

3. You're on a ship that has broken down and is preparing to be taken in tow. You will use your anchor cable as part of the towline. Which statement is TRUE?
 - A. The anchor cable should be veered enough to allow the towline connection to be just forward of your bow.
 - B. The anchor cable should be veered enough to allow the towline connection to be immediately astern of the towing vessel.
 - C. The strain of the tow is taken by the riding pawl, chain stopper, and anchor windlass brake.
 - D. The anchor cable should be led out through a chock, if possible, to avoid a sharp nip at the hawsepipe lip.

4. Which statement is TRUE about sail shape?
 - A. You can move the belly up in a mainsail by easing the luff tension.
 - B. A high-aspect ratio Marconi mainsail is more efficient for downwind sailing than a gaff-rigged mainsail.
 - C. You can reduce the belly in a boomed mainsail by easing the sheet.
 - D. You should put more belly in a sail in light airs than in a strong breeze.

1. *Note: The line fuses supplying a three-phase motor may be tested off-line using a voltage tester or a multi-meter set up as a voltmeter.*

- | | |
|------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A. The fuses must be removed from the circuit. | Incorrect answer. To test the fuses on-line using a voltage tester, the fuses must remain in the circuit. |
| B. The starter must be placed in the STOP position to stop and disconnect the motor. | Correct answer. The motor must be stopped to prevent back-feeding of voltage to the bottoms of the fuses, which would result in erroneous voltage readings. |
| C. The three line connections in the motor terminal box must be disconnected and tagged. | Incorrect answer. To test the fuses on-line using a voltage tester, the line connections to the fuses must be connected to the fuses and the line connections must be energized. |
| D. Nothing need be done as long as the motor is running under a light load. | Incorrect answer. The motor must be stopped. See explanation for choice "B." |

2. *Note: A salinometer is an instrument used to measure the chloride (salt) content of a solution. It measures the electrical conductivity of the solution, which is proportional to the chloride content. For accuracy, the salinometer reading must be corrected for temperature.*

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|----------------|---------------------------------------------------------------------------------------------------------------------------------------|
| A. pyrometer | Incorrect answer. A pyrometer is used to measure very high temperatures, such as diesel engine exhaust and boiler stack temperatures. |
| B. thermometer | Correct answer. An ordinary thermometer is used to correct for the effects of temperature. |
| C. hygrometer | Incorrect answer. A hygrometer is used to measure the moisture content of the atmosphere. |
| D. hydrometer | Incorrect answer. A hydrometer is used to measure the specific gravity of a liquid. |

3. *Note: While cold weather starting of diesel engines can be difficult due to the thickness of the lubricating oil, this can be compounded by a reduction in torque that the starting system provides.*

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|----------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A. direct cylinder admission air start | Incorrect answer. The starting torque produced is primarily a function of the piston crown area and the starting air pressure, which are not significantly affected by cold temperature. |
| B. hydraulic | Incorrect answer. The starting torque produced is primarily a function of hydraulic motor piston area and the starting hydraulic pressure, which are not significantly affected by cold temperature. |
| C. electric | Correct answer. The starting torque is primarily a function of the battery's internal resistance and the specific gravity of the electrolytes, which are significantly affected by cold temperature. |
| D. air motor starting | Incorrect answer. The starting torque produced is primarily a function of the air starting motor vane area and the starting air pressure, which are not significantly affected by cold temperature. |

4. *Note: Pitting on the inside of boiler tubes is generally the result of oxidation corrosion.*

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|-------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A. waterside deposits are present | Incorrect answer. Waterside deposits generally result when the mineral content of the boiler water causes hard scale formation. |
| B. sludge is present | Incorrect answer. Sludge accumulations are generally the result of soft precipitates forming in the boiler water as a result of boiler water treatment for scale control. Sludge settles to the bottom of the boiler. |
| C. dissolved oxygen is present | Correct answer. Excess dissolved oxygen in boiler water causes localized pitting corrosion in the boiler tubes. Excess dissolved oxygen can be caused by defective deaeration equipment or inadequate dosage with oxygen scavenger treatment chemicals. |
| D. the tube metal acts as a cathode | Incorrect answer. Galvanic corrosion in modern boilers is generally not problematic due to the avoidance of constructing boilers with dissimilar metals. Any corrosion, however negligible, would be at the anode. The cathode would be protected. |

1. A. a vessel engaged in fishing, at anchor Incorrect answer.
 B. a vessel restricted in its ability to maneuver, at anchor Incorrect answer.
 C. a sailing vessel, at anchor **Correct answer.**
 "A vessel at anchor shall at intervals of not more than 1 minute ring the bell rapidly for about 5 seconds."
 Reference: International and Inland Rule 35(g).
 D. all of the above Incorrect answer.

2. A. 063° Incorrect answer.
 B. 068° Incorrect answer.
 C. 073° Incorrect answer.
 D. 079° **Correct answer.**
 Where: $A = \text{"The angular difference between the target vessel's true course and the true bearing of your vessel from the target vessel."}$
 $A = 133^\circ - (42^\circ + 180^\circ)$
 $A = 89^\circ$ (make this value positive for calculator solution)
 Target speed = 6 knots
 Own vessel speed = 10 knots
 Sin of the intercept angle = (target speed \times sin A) \div (your speed)
 Sin intercept angle = $(6 \times \sin 89^\circ) \div (10)$
 Intercept angle = 36.86°
 True course to steer = intercept angle (\pm) target bearing
 (positive if target bearing falls to the right, and negative if target bearing falls to the left)
 True course to steer = $36.9^\circ + 42^\circ = 78.9^\circ$
 Reference: Richard M. Plant, *Formula for the Mariner*, 2nd Ed., p. 32.

3. A. The anchor cable should be veered enough to allow the towline connection to be just forward of your bow. Incorrect answer.
 B. The anchor cable should be veered enough to allow the towline connection to be immediately astern of the towing vessel. Incorrect answer.
 C. The strain of the tow is taken by the riding pawl, chain stopper, and anchor windlass brake. **Correct answer.**
 "If the anchor cable is used, the hawser is secured or shackled to it and the cable veered away to the desired length; the windlass brakes are then set up and springs or chain stoppers used to take the real strain of towing."
 Reference: John V. Noel, Jr., *Knights Modern Seamanship*, 17th Ed., p. 303.
 D. The anchor cable should be led out through a chock, if possible, to avoid a sharp nip at the hawsepipe lip. Incorrect answer.

4. A. You can move the belly up in a mainsail by easing the luff tension. Incorrect answer.
 B. A high-aspect ratio Marconi mainsail is more efficient for downwind sailing than a gaff-rigged mainsail. Incorrect answer.
 C. You can reduce the belly in a boomed mainsail by easing the sheet. Incorrect answer.
 D. You should put more belly in a sail in light airs than in a strong breeze. **Correct answer.**
 "A slack foot introduces more belly into the sail, especially in the lower part of the sail. This is desirable for light winds, when the airflow can remain attached (laminar) over a deeper curve than in stronger winds."
 Reference: G. Andy Chase, *Auxiliary Sail Vessel Operations*, p. 55.

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